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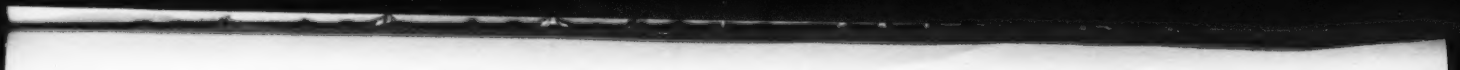

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ACTIVITIES AND FUNCTIONS OF THE DIVISIONS OF THE S. P. E. E.

By FRANK L. EIDMANN, Columbia University

Chairman, Middle Atlantic Section, S. P. E. E.
Chairman, Machine Design Division, S. P. E. E.

Growing interest is being shown in the activities of the Divisions of the Society. The formation of new Divisions has been approved by Council within the past few years. Two comparatively recent developments in the Society are primarily responsible for bringing together members who have common interest in certain of the subjects which are taught in engineering colleges: (1) the summer schools which were operated under the direction of Professor H. P. Hammond, and (2) the preconvention conferences which are held in conjunction with the annual meetings of the Society.

One of the principle functions of the Society is to offer opportunity for teachers to consider problems peculiar to instruction in engineering colleges. With the brief time available for the annual meeting of the Society and with the large number of subjects now offered in engineering colleges, it is obviously necessary to confine the papers of the main sessions to topics of general interest. It is logical, then, to arrange for discussion groups and conferences to afford opportunity for those who are interested in the teaching of the various subjects in the engineering curriculum to meet with others interested in the same subjects, for the purpose of discussing problems of mutual interest. It is, of course, not necessary to form a Division of the Society in order to hold these conferences. If, however, a fairly large number of members show active interest in the conferences of a group over a period of years it may be desirable to organize and to apply for recognition as a Division of the Society. The principal advantages in doing this are (1) the establishment of a group of which the planning and administration is likely to be more efficient because it will be done by members who are elected for their enthusiastic interest in the particular work of the group; (2) a self-perpetuating governing committee may be planned; (3) continuity of program; (4) better acquaintance of members in a group; and (5) better recognition of the work of the group by the membership of the Society and by the colleges.

A Division should be formed only when a sufficiently large number of members show a sustained interest and participate in the activities of the group. Even then it is advisable for the group to

function as a committee for a few years. Then, if there seems to be reasonable assurance of continued interest the group may petition the Council of the Society for recognition as a Division.

The possible activities of a Division are many. Of first importance is the arrangement of the program for the conference to be held in conjunction with the annual meeting of the Society. In this connection it should be pointed out that papers presented at the conferences should deal with the teaching aspects of subjects taught in engineering schools rather than with the technical aspects of engineering problems. The presentation of the latter should be left for the programs of the professional societies. I have heard many members express this thought. A second activity might be an organized method of exchanging ideas regarding the teaching of the subject. The Machine Design Division has for several years operated the Machine Design Clearing House. Individual members submit problems, ideas and discussions to the chairman who has these manifolded and mailed to the membership. Eighty members, representing engineering colleges over the entire country, are enrolled and are active in the Clearing House. Six or seven bulletins are mailed during the college year to those who contribute to the financial support. For the past year an assessment of fifty cents was sufficient to cover the expenses of printing and postage.

Another activity which offers possibilities is the coöperation of the Divisions with the professional engineering societies. As an example, the Machine Design Division of the S. P. E. E. and the Machine Design Committee of the American Society of Mechanical Engineers are planning to conduct a joint session at the annual meeting of the A. S. M. E. It has been very gratifying to find the engineering society very anxious to coöperate. The contact should prove valuable not only to the teacher and the practicing engineer but should indirectly benefit the student of engineering.

It has been suggested from time to time that arrangements be made at meetings of the various Sections of the Society for conferences or round-table discussions. Some of us have hesitated, feeling that these conferences might detract from the attendance at the general sessions, and that if a number of conferences were held, each group would necessarily have a very small attendance. The suggestion has persisted, however, and it is our plan to try out the idea at a meeting of the Middle Atlantic Section.

There are other worthwhile activities which Divisions might pursue with resultant great benefit to all who participate. For instance, now that there are no longer provisions for the extended summer schools under Society sponsorship, I believe that Divisions could successfully plan and operate summer conferences of this kind and that they could be made self-supporting.

In summary, I express my firm belief that active Divisions of the Society may make important contributions in the development of engineering education; that they should be self-supporting; that technical aspects of engineering do not have a place in the program; and that recognition as a Division should be withdrawn if there is a lag in activity.

CIVIL ENGINEERING DIVISION

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THE COMMITTEE ON STRUCTURAL ENGINEERING

BY L. E. GRINTER, Texas A. and M. College

The Structural Committee was not organized until September 1935 and, therefore, it is still in the embryo state. We hope that it will soon grow into maturity to help in the development of a useful subdivision of the Division of Civil Engineering. The personnel of the committee was drawn from widely separated schools so that many viewpoints would be represented. However, there is a distinct unanimity of opinion that the time has arrived when teachers of structural engineering should review their objectives. It has been suggested that "much water has passed under the bridge" since our courses in theory and design of reinforced concrete were organized. Another member believes that we are "centering the students' attention on interesting new developments at the expense of more fundamental instruction in classic methods." Might he not be referring to structural welding?

Certainly there will be an opportunity offered to the members to discuss these subjects at the annual meeting in Madison, Wisconsin. However, the presentation of papers explaining the results of scientific research, which attracted so much favorable comment at Ithaca and Atlanta, will also be continued. An attempt will be made to limit such papers, however, to such subjects that are of *vital interest* to teachers of structural engineering.

Your committee would appreciate your suggestions of subjects for discussion. Perhaps you know where an interesting paper is lurking under the surface of a cluttered desk. We need your assistance.

SANITARY ENGINEERING

BY R. G. TYLER, University of Washington

The Sanitary Engineering Committee has been carrying on a discussion through the mails of certain matters pertaining to the teaching of its subject matter. As the conclusions of the Committee will not be reached until after the Madison meeting, we are reporting at this time only the questions being considered.

Methods of teaching sanitary engineering subjects vary widely in different institutions. Can a method be developed from a consideration of these which will be generally acceptable?

Is the present practice of assembling the desired subject matter under the two major headings of Water Supply Engineering and of Sewers and Sewage

Disposal the most satisfactory arrangement possible? The Committee is considering the desirability of arranging all of the material on Hydraulics and Hydrology in one course, leaving the remaining subject matter of Water Purification and Sewage Disposal for a second course.

The Committee is divided in opinion as to the desirability of a sanitary biology and chemistry laboratory course to precede the courses at present given. This might be placed in the junior year, as has been satisfactorily done by one member of the Committee.

Other matters under discussion pertain to the desirability of placing sanitary engineering and other engineering options in a fifth year following a four-year basic engineering course containing more general cultural and economic subjects.

SPECIAL BULLETINS

The council of this Division has decided to issue at least two special bulletins of interest to teachers of Civil Engineering subjects. It is planned to issue the first of these bulletins during February and to mail copies to all known teachers of Civil Engineering in this country. Later issues will be sent to those teachers who are members of the division. If you do not receive a copy of this first bulletin please notify the secretary or chairman of the Division.

THE COMMITTEE ON FOUNDATIONS AND SOIL MECHANICS

By ARTHUR CASAGRANDE, Harvard University

The engineering teacher, as well as the practicing engineer, in the field of Soil Mechanics and Foundation Engineering, is confronted with considerable difficulties in keeping abreast of the developments in this field. At present the question what to teach and what not to teach is of far greater importance than questions of technique of teaching. Thus, the principle purpose of this Committee is to aid in collecting and coördinating information from field observations and laboratory investigations which are not yet readily available. Such work will not only benefit greatly those who are doing it but it will constitute a real service to further progress in our general understanding of the behavior of soil.

Along such lines the work of the Committee is being organized. Those among the members of the Committee, as well as other teachers who wish to coöperate need not have a large and well equipped laboratory for this purpose. Such work does require, however, sufficient time and some financial support by the individual Institution to permit visits to construction projects and to one of the more important Soil Mechanics laboratories.

It may be well to call attention of all those who are interested in teaching this subject to the International Conference on Soil Mechanics and Foundation Engineering which will meet from June 22 to 26, 1936, at Harvard University. Those interested in the details should apply for the printed pamphlet containing all necessary information, to "Foundation Conference," Graduate School of Engineering, Harvard University.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Atmosphere: One of the important educational by-products of engineering drawing departments might well be classified as "drafting room atmosphere." Like many of the by-products of engineering education "atmosphere" is not a result of teaching: it is one of the many intangibles produced by the manner in which work is conducted and by the character and habits of the instructors with whom students work.

The two important elements which assist materially in producing the right atmosphere in the drafting room are (1) the attitude of the students toward the work being done and their conduct in performing this work; and (2) the appearance of the drafting rooms and offices in the department.

It goes without saying that interest in their work; diligence and energy applied toward its accomplishment; and the quiet, industrious atmosphere of efficient and workmanlike production is as necessary on the part of instructors as it is on the part of students. When an instructor displays such an attitude toward his work, it will be reflected by the attitude of the students and conditions in student drafting rooms will approach the ideal.

It also is true that when drafting rooms are dirty, poorly arranged and equipped and lighted, neither good work nor a good attitude toward their work may be expected from students. Conditions in student drafting rooms in these respects, important as they are, are often overshadowed by conditions in staff offices. When a student enters an office and finds there lack of order. general untidiness, and an atmosphere of careless attention to appearances, he is not subjected to influences of the right kind.

Perhaps because these important elements are by-products is the reason they are overlooked. Some thoughtful consideration of the value of "atmosphere" is worth while and the creation of the right atmosphere brings desirable contributions to student development.

National Drawing Competition

Regulations for School Year, 1935–1936

1. Work is limited to first year drawing courses. (This is intended to mean any student who is enrolled in a college engineering drawing course, if that student has not been enrolled in an engineering drawing class of college grade in any previous school year or if he has not been professionally employed as a draftsman.)

2. An engineering drawing department may submit one drawing only in each class: AP, AT, AI, BP, BT, BI, C, D, and E (does not refer to school classes).

3. Each submitted drawing must be accompanied by a statement concerning the following information.

(*a*) The competition class in which the drawing is to be entered.
(*b*) The name, address, and institution of the drawing teacher.
(*c*) The number and length of lecture or class periods, the number and length of drawing room periods, and the number of "home work" periods which were available to the student prior to and including the time spent on the submitted drawing.
(*d*) The number of units, semester hours credit or yearly credit, of mechanical drawing earned by the student competitor before entering college.
(*e*) The name and address of the student whose drawing is submitted.

4. The problems and special specifications supplementing these general rules will be furnished schools desiring to enter contestants. Application should be made to the Chairman of the Competition Committee, Carl L. Svensen, Box 933, Lubbock, Texas, who will supply the necessary problem specifications and identification numbers for the contestants. Specifications will be furnished contesting students through their instructors. The schools' best drawing in each class will be entered in the National Competition. An elimination contest in each school is suggested as one means of selecting the best drawing.

The Classes in General

In all cases the drawing is to be made from the problem project supplied by the Drawing Competition Committee and in accord with the specifications and regulations which apply to the particular classification.

Class AP.—Required: A pencil drawing made with instruments embodying orthographic shape description. Choice and treatment of views, as well as execution are a part of the problem.

Class AT.—Same as Class AP except that a pencil tracing (accompanied by the pencil drawing) is required.

Class AI.—Same as Class AP except that an inked tracing (accompanied by the pencil drawing) is required.

Class BP.—Same as Class AP except, required: A pencil drawing made with instruments, including both an orthographic shape description and size specification. Choice and treatment of views, execution, dimensioning, etc., are part of the problem.

Class BT.—Same as Class BP except that a pencil tracing (accompanied by the pencil drawing) is required.

Class BI.—Same as Class BP except that an inked tracing (accompanied by the pencil drawing) is required.

Class C.—Required. A complete working (shop) drawing submitted in the form of an inked tracing accompanied by the pencil drawing. Choice and treatment of views, dimensioning, etc., are a part of the problem.

Class D.—Required: A freehand pictorial sketch. Choice of position, method of representation, execution, etc., are a part of the problem.

Class E.—Required: Lettering in pencil and lettering in ink from written copy. Arrangement, form and proportion of letters, execution, etc., are a part of the problem.

Judging

First and second places will be awarded in each class except that no awards will be made for any class in which there are not at least five entries.

Theory, practice, technique, and student judgment shall constitute the basis for judging all drawings.

The judges shall be three in number selected by the Chairman of the Division of Engineering Drawing. The Chairman of the National Competition Committee shall be, ex-officio, a non-voting member of the judging committee.

REPORT: PROGRESS IN ENGINEERING EDUCATION 1934–35

Society for the Promotion of Engineering Education

NOTE: This first report is frankly a venture in a new field. Comments by members on the general scope of the report and suggestions for amplification next year will be appreciated by the Committee and may be sent to the Chairman, Charles F. Scott, Yale University, New Haven, Conn.

First Report of Committee on Progress.—The purpose of the Report of Progress is to make record of the significant events, developments and trends in the field of Engineering Education; each Annual Report a scene "in the panorama of the unfolding years."

The Officers, Members of the Council, and the chairmen of committees and of conferences of the S. P. E. E. were requested to report items which appealed to them as meriting a place in the record for the academic year 1934–35. Their contributions form the principal basis upon which the Committee has formulated the following report.

THE ANNUAL CONVENTION, JUNE 1935

Looking Ahead.—This keynote of the Annual Convention was given historic background by President Williams in his address on "The New Epoch in Engineering Education." (Sept. '35, p. 6)* The Epoch of Beginnings, beginning about a century ago, merged into the second, Curriculum Building, following the Morrill Act in 1862. The Epoch of Research began with the first experiment station in 1903. Now we enter a fourth stage, Economic Adjustment. What engineering will become will not be what we of this generation see in the industry ahead; it will be limited only by the abilities and the purposes of our young men. Industry of to-day will not shape their destiny; they will fashion industry of tomorrow. To ascertain and to cultivate their individual potentialities is the problem of Engineering Education.

The General Sessions attested by the major divisions of the program the widening scope of the activities of the Society. "Undergraduate Engineering Education in the Future" (formerly the whole program concerned undergraduate affairs) included a report on Objectives and Length of Curriculum (Oct. '35, p. 112) which

* References are to JOURNAL OF ENGINEERING EDUCATION.

presented a succinct summary of the 1935 status of this major problem; the usual four years were found not suited to all conditions. "Graduate study" (Dec. '35, p. 313) included a notable committee report reviewing the field in which enrollment increased tenfold in a decade. "Research as an Instrumentality in Engineering Education" (Dec. '35, p. 356) was presented as a device of educational value in which addition to scientific knowledge is a by-product rather than the objective. "Professional Status and Employment of Graduates" (Nov. '35, p. 165) evidenced the alert interest of schools, profession and industries in the post scholastic period. "Relation to Engineering Societies" was presented by C. E. Davies, Secretary A. S. M. E. and former Secretary E. C. P. D., who indicated the broad relationships between professional and educational societies.

The Group Conferences, (Nov. '35, p. 249) held preceding or interspersed with the sessions of the convention, initiated on a major scale by President Wickenden at the Cornell convention in 1934, continued their vigor and vitality as a part of this year's program. They are incident to the new place taken by graduate study and research in the engineering education picture. The phenomenal technical advance since the turn of the century could not fail to affect engineering education. When organized in 1893, S. P. E. E. was designed for the engineering previous to the recent impact of research and of advanced science—new instrumentalities of education which necessitate different techniques and procedures. The conferences are an addition to S. P. E. E. activities corresponding to the increment to education in the past quarter century. They represent the youth of the profession; their work is the cambium zone of engineering education. They are technically productive and serve as an agency for the stimulation and coördination of the research phases of engineering education. Soil mechanics and continuous structures are dividing honors for attention in civil engineering; manufacturing processes and machine design in mechanical engineering; electronics and illumination in electrical engineering; hydrogenation and synthetic products in chemical engineering; metallurgy of alloys and petroleum production in mining engineering.

The conferences, allotted two forenoons and one evening, were sponsored by 14 committees with an average of 10 members; Chemical Engineering, Civil Engineering, Coöperative Engineering Education, Drawing, Electrical Engineering, English, Industrial Engineering, Junior Colleges, Machine Design, Manufacturing Processes, Mathematics, Mechanical Engineering, Mechanics and Physics. Papers presented numbered 114. Interest in the conferences induced attendance on a par with the second largest at

an annual convention—one dean remarked that the 21 from his school had come 500 miles for the conferences. Reports of the conferences cover 60 pages of the November 1935 JOURNAL. Further notes of the conferences in civil and in chemical engineering are here given as illustrations of the type of work done by these conferences:

Civil Engineering Division.—"A group of members for the consideration of questions which relate particularly to that group" was formed in Civil Engineering June, 1934, and presented a year of outstanding activity and accomplishment. It is organized with an executive council and eight committees. (1) Educational Policy and Teaching Methods; (2) Structural Engineering; (3) Sanitary Engineering; (4) Transportation; (5) Applied Hydraulics; (6) Construction Education; (7) Foundations and Soil Mechanics; (8) Geodesy and Surveying. This organization includes 59 individuals from 41 institutions in 30 states. Members of the division presented 24 major papers, four at general sessions and the others at six group conferences.

Current trends are recognized in the demands on the trained civil engineer; *e.g.* in Transportation, opportunities for the young engineer will appear in the organization, operation and management branches of coördinated systems; applied hydraulics dealing with flood control and water supply and navigable streams should be based on the recent findings of hydraulic laboratories; soil mechanics is a new scientific approach to the solution of engineering problems in which earths are factors such as excavations and embankments; courses in Construction Education to be introduced into the civil engineering curriculum are being planned on basic principles dealing with construction methods, economic considerations, and personnel organization.

Chemical Engineering.—There is a new activity of the chemical engineering group in the S. P. E. E. The outstanding feature of the conference at the Convention in June was the report of the Laboratory Committee. It is a comprehensive summary of the methods used in various schools in instruction in Chemical Engineering. The data received had been compiled and classified in order to afford a clearer and more uniform conception of objectives and the methods by which they might be achieved.

GRADUATE STUDY IN ENGINEERING

The phenomenal growth of graduate work in engineering (in 12 years the advanced degrees conferred increased from 178 to 1,197 and graduate enrolment in engineering advanced from 10th to 2d place among the sciences) prompted the appointment of a

committee in 1933 for the study of status and trends. Professor H. P. Hammond is chairman. The U. S. Office of Education has joined in the collection, tabulation and publishing of data. The report is a masterly achievement. The first installments of results presented in June included the following topics: Résumé of the History of Graduate Work; Growth and Present Magnitude; Part-time and Coöperative Graduate Courses; Subsidized Opportunities for Post-Graduate; Scholarships and Fellowships; Relationships of Post-Graduate Work to the Faculty; Relationships to Undergraduate Work; Examination Methods and Employment of Graduates. Additional topics to be presented next year are Organization and Administration; Basic Nature and Objectives of Graduate Work; Admission and Graduation Requirements; Thesis; Foreign Language Requirements; Degree Practices; Costs and Facilities.

Engineers' Council for Professional Development

Committee on Student Selection and Guidance.—Dean R. L. Sackett, Chairman, is concerned with guidance programs and with methods of selection of students. It advocates a counsellor service by groups of engineers; the distribution of "Engineering; a Career —a Culture" and its use by the counsellors; it encourages guidance conferences such as are conducted in summer camps by Stevens Institute of Technology, Lafayette College and Worcester Polytechnic Institute. It is instituting tests in various institutions to determine the correlation between these tests at entrance and the first and the four year records; it seeks means for determining attitudes which may show engineering ability; it is seeking with the aid of the division of drawing to develop a new test of ability to visualize. Progress is being made in the organization of local committees on professional training in selected communities.

Committee on Engineering Schools, President Karl T. Compton, Chairman, has been constituted as the official agency for accrediting engineering schools and colleges and plans to undertake accrediting in the New England and Middle Atlantic states in November 1935. As E. C. P. D. represents the three divisions of the profession chiefly concerned with the problem of accrediting (the professional societies, the engineering colleges and the state licensing boards) it is the only agency under which this important movement in the history of engineering education may be undertaken under sufficiently inclusive auspices.

Committee on Professional Training, Gen. R. I. Rees, Chairman, aims to aid the young engineer (after his graduation) to attain full professional status. "Suggestions to Junior Engineers" includes an outline for personal appraisal and a reading list in the

field of general knowledge; there is also a selected bibliography of engineering subjects. A bulletin of nation-wide educational facilities available to employed men has been prepared. A Junior committee is actively aiding to make effective a development program for young engineers. In some localities members of the Sections of the several National Engineering Societies are forming joint advisory committees.

Committee of Professional Recognition, C. N. Lauer, Chairman, is continuing its study of the difficult problem of selecting the criteria essential to full professional status.

Trends

Mechanical Engineering.—The following developments and tendencies are noted: (1) More attention to machine design and related subjects from the viewpoint of analysis and the application of advanced mechanics; (2) growing appreciation of the mechanics and dynamics of fluids; (3) a shift from manual training type of shop courses to research in shop processes; (4) shift from drafting work in machine design courses to stress analysis and computation.

Mining Engineering. (Feb. '36 p. 440)—There is a realignment in the relation between Mining, Metallurgy, Petroleum, Natural Gas and associated geological programs to meet the new contribution of science and the new industrial conditions.

Public Service Engineering.—The increasing proportion of engineering graduates, especially the younger men, who are finding employment in city, county, state and Federal service indicates a trend which will doubtless continue and will, at least in part, be permanent. This would be an added reason for keeping the undergraduate curricula broad, rather than specialized.

Trends and Procedures.—The following significant items—some local, some general—are contained in letters received by the committee.

"Honors Courses" mark a departure from regimented instruction to emphasis on individual initiative and scholarly ability for semi-independent achievement.

A satisfactory alternative for a separate curriculum in administrative or industrial engineering has been developed at the Case School of Applied Science by offering as an option of a selected group of studies occupying half of the time in the senior year. It is chosen by a third of the class. Somewhat similar options are offered elsewhere.

The movement to include the first two years of all undergraduate courses in a single, general course, under the direction of a junior college or division, is making headway. This plan has re-

cently been put into effect at the University of Florida. Engineering students, with a broadened base of general education, attain graduation at the end of either two or three more years.

The undergraduate curriculum concentrated on fundamentals is becoming an accepted form of liberal education as it gives acquaintance with the processes, devices and methods which make out civilization distinctive.

Engineering touches the life of every person in an industrial nation and the general well being is distinctly dependent upon the education of the engineer.

Some of the highest administrative posts in large universities are occupied by engineering educators. Illinois and Virginia have recently chosen engineers as Presidents; California also has an engineer and Tulane an engineer as Acting President; within recent years Maine and Mississippi Universities have had engineer Presidents.

Miscellaneous Items

Employment of Graduates.—Reports indicate that a large proportion of the engineering graduates in the four depression years were satisfactorily employed in the fall of 1934; graduates of arts colleges were less fortunate. The significant conclusion is that business and industry give preference to men with engineering training. Openings for recent graduates are to a large extent found outside of the normal (1929) channels. Small industries find college-trained engineers useful. Mechanical and electrical activities are recognizing consumer goods as well as durable goods; industrial readjustments call for more engineers for application and operation than for design, which in turn puts a premium on adaptability in graduates.

The eighth Lamme medal was awarded to William Elgin Wickenden for accomplishment in teaching and advancement of the art of technical training.

The second Volume of the Report of the Investigation of Engineering Education containing bibliography and complete index was issued during the year; a Summary Report of 40 pages was also issued.

The 1935 Convention was held in the South presided over by a Northern president; the 1936 Convention is scheduled to be held in the North (Madison, Wisconsin) presided over by a Southern president.

The formation of two important new sections of the Society and the increased activity of local sections generally signify a local consciousness and a disposition to study educational problems more

intensively. The new sections are: Illinois-Indiana and Iowa-Wisconsin.

At the Atlanta Convention a committee was authorized to study how management courses may be included in engineering curricula.

The discontinuance of engineering instruction at the universities of Oregon, South Dakota, and North Carolina as a result of state policies and the organization of the Minnesota Institute of Technology (to include engineering, architecture, mines and metallurgy, and chemistry) are noteworthy events of the year.

F. E. R. A.—Through the appropriations made available to the Federal Emergency Relief Administration (later changed to National Youth Administration) ten per cent of the students of each collegiate institution were enabled to earn up to a limit of $15.00 per month by rendering services of a "socially desirable nature" to the institution, the money for the services being paid by the Federal Government. Most engineering colleges availed themselves of this opportunity and many students were enabled to continue their collegiate education.

The number of freshmen in the fall of 1930 was approximately 25,000. This dropped in 1932 to approximately 17,000. In the fall of 1935 the number was about 20,000. (Dec. 35, p. 312)

Committee:

M. L. Enger, R. H. Fernald,
E. A. Holbrook, A. H. White,
Chas. F. Scott, *Chairman*

CHANGES IN MINING EDUCATION *

By E. A. HOLBROOK

Dean, Schools of Engineering and Mines, University of Pittsburgh

Since the S. P. E. E. Investigation important changes have occurred in mining education. By the subject of changes in mining education I include changes in mining, metallurgy, petroleum, natural gas and associated geological educational programs. A few years ago, we had schools and departments of Mines which generally offered one general mining course with a few appropriate options. Today we have marked specialization in Schools of Mines, with several distinct four year courses taking the place of the old general mining course. Within the past ten years also there has developed the tendency to do away with the older term "School of Mines" in favor of a broader school designation as "School of Mineral Industries," "School of Mineral Technology" or "School of Mining and Metallurgy." Even in universities where there is no separate School of Mines, but where the mining department is a part of a school of engineering, we now may have a department of mining and metallurgical engineering, or separate departments of mining engineering and metallurgical engineering. Separate departments of petroleum and natural gas engineering have appeared. One or two universities even have established separate schools of petroleum engineering. Altogether college education in the general field of the mineral industries is undergoing a rapid change in administrative organization, coming from a recognition that the old basic mining course is no longer adequate to prepare men for the present specialized fields in mining, in metallurgy, in petroleum and natural gas engineering, in petroleum refining, in ceramics and in geological engineering.

The late twenties and the early years of the depression were years of decreased activity in the mining industries. As a result, there was a decreased enrollment in many of our older schools of mines, especially those situated in districts where there was little interest in the rapidly developing fields of metallurgy and of petroleum. This led to these mining schools expanding their curricula into other fields of engineering and four year courses in civil,

* This article details some of the changes that are taking place in mining curricula. I wish that several engineering educators might in similar articles cover changes in Civil, Mechanical, Electrical, Chemical and other standard engineering branches.

mechanical, electrical and chemical Engineering have been introduced into some former schools of mines.

Perhaps the tendency in this country to have schools of mines separate from schools of engineering had its inception in the old Bergacademié at Freiberg, Germany, which was definitely mining in character and older than the engineering schools of Germany. Likewise in this country the school of mines at Columbia University was the first distinct mining school and was closely paralleled in organization by other mining schools located later in various mining regions. As against this separate mining school plan, we early had the mining department of the Massachusetts Institute of Technology which was one of several engineering departments in an engineering school. This plan has been followed in the establishment of mining departments in many of our state universities and private colleges.

The question arises—In American colleges are we going to continue schools of mines under broadened names and concentrate in them the rapidly expanding curricula in coal, metal and general mining, in oil and gas engineering and refining, in ferrous and nonferrous metallurgy, in non-metallic minerals production and in geology and other minerals industries branches; or should these branches be departments in a general school of engineering? The logical place for mining, metallurgical, petroleum and other engineering courses connected with the mineral industries is in a school of engineering. The courses offered are all engineering in fundamentals and most of them are engineering in course content. For example there is a close connection between many courses in mining engineering and courses in civil or mechanical engineering. There is also a close connection between courses in metallurgical engineering and many courses in chemical engineering. The same type of student we find both in engineering and in mining schools. The type of classroom and laboratory work is similar in both schools; even the professors in the mining schools often have been graduates of an engineering school. Looking at the question from a rationalized point of view it is difficult to see the need at any single institution of a school of mines or of petroleum as distinct from a school of engineering or as to why there should be different administration and faculties of the two schools.

We must seek for a reason in historical background or in environment. In Michigan for example, we see the State University with its great engineering college in a section of the state far removed from mining activities. What could be more logical than the establishment of a school of mines on the northern peninsula adjacent to the mining regions. In Missouri, Colorado, South Dakota and Montana similar considerations led to the establishment

of separate schools of mines. On the other hand, Illinois, Alabama, Kansas and other universities have cared for mining and allied branches as a part of an engineering school, principally because of location and existing facilities in a going university. A third condition exists at such institutions as Pennsylvania State College, University of Pittsburgh, California, Nevada and others. In the states where these universities are located, mining long has been a predominant industry and deserving of special consideration in engineering education. At these universities we have separate schools of mines in institutions where there are also engineering colleges. Their existence is justified by reason of legislative or private grant or because the engineering school is not able to give the special attention to mining which its importance there deserves. It has also been held that in these states, research in mining and allied subjects is so important and so specialized that a separate school with separate funds and independent administration is justified.

In any case it appears that progress in mining and allied education can best be fostered in the following ways:

(1) Since we have at present in this country at least 43 colleges offering work in mining and allied branches, new departments or schools of mines should not be established.

(2) It has not been for the best interest of the mining and allied students to isolate them in a school devoted solely to mining. Either the school should be broadened to include other engineering branches or the school of mines should work in close coöperation with the engineering school existing on the same campus, or in allied institutions.

(3) The average mining and allied department, where large numbers of students are not involved, may be conducted successfully as departments of the engineering school, provided that the engineering administration has some knowledge of and sympathy with the problems of the mining departments.

(4) Departments connected with the mineral industries, where extensive research in these fields is carried on, have the greatest justification for existence as a separate school.

THE THEATRE IN THE ENGINEERING COLLEGE

By HAROLD BURRIS-MEYER

Assistant Professor of Humanities, Stevens Institute of Technology

It has become increasingly apparent during the past decade, that engineering colleges have a horror of falling into the trade school category. If an arts college graduate was a boor, his education didn't take, but the uncultivated enginner, poor fellow, never had a chance to become a gentleman by taking a course in philology or the very minor poems of Milton. Obviously something had to be done to civilize the engineer. Engineering students have therefore been subjected to assorted kinds of hypodermic culture from formal rhetoric to counterpoint, depending upon the abilities and imagination of faculties and administrations.

As in all educational schemes, those roads to culture which provide for education by participation have carried the most traffic and have, in general, led the largest number of students far enough toward their goal to assure their continued pursuit of wisdom after graduation. There are, of course, many cultural subjects which may be pursued by participation, but one which seems particularly well adapted to the engineering curriculum is the theatre.

To be successful as a cultural agency in an engineering college, an enterprise must have an initial appeal to a large number of students. This the theatre has. In addition to attracting the usual group of stage struck students and exhibitionists normally drawn to it, the theatre provides opportunity for self expression in most of the standard hobbies to which engineering students devote their time. The theatre needs the designer, the painter, the electrician, the machinist, the irrepressible business manager, the carpenter, the radio hound, the musician and the general gadgetologist. The student finds his way into the theatre via his hobby. He gets a job for which he alone is responsible. He starts to think in terms of the season's production schedule. His cultural education in the theatre is begun.

In the course of theatrical apprenticeship the student will probably work back stage on a number of productions. He will probably know every line of every play in which he works. He will know the kind of interpretation given the piece and the reason for it. It is unnecessary to assert the value of the drama as a cultural study, but it may not be amiss to emphasize the fact that in the production of one play the student learns more about the drama

than he can in reading the scripts of fifty. Moreover, since the theatre is the art which is most typical and interpretive of its age and the society which produces it, the student in the theatre often learns more of the way in which people have thought and acted in Greece of the third century B.C., nineteenth century Russia or in the West Virginia coal mines, than he could in many courses in history, sociology or economics. And when one finds, as the writer recently did, a group of engineering students making a game of conducting the dinner table conversation in iambic pentameter, it seems as if the theatre has given a vitality to poetry which few courses in that subject could improve upon.

In preparing the scenic investiture of a play and in planning its direction, the fundamental principles common to all the arts—harmony, emphasis, proportion, rhythm, balance, etc.—must be understood and used. The student in the theatre learns them not as an academic chore, but because he feels helpless without them. And so from his training in the theatre comes an understanding and appreciation of the plastic arts, the dance and music. The man who has labored to learn, understand and deliver a line by Shaw, and discovered, in contrast, the simplicity of the Shakespearean line, has some pretty sound ideas on rhetoric, and does not scoff at the poetic drama.

No less obviously valuable than the cultural training gained from the theatre is practical engineering experience. The American theatre technically is simple enough for anyone, but the engineering student in the theatre will not have it so. As soon as he begins to understand the dramatic use of light, he will design and build lighting apparatus with which he can often do a better job than is usual in the commercial theatre. He will work out elaborate inter-communication systems because nobody wants to be a call boy. Labor-saving devices become a fetish with him, with the result that the stage will become a mechanical and electrical maze, and a play will run with half the crew required for a similar production in the commercial theatre.

Moreover, whatever the student designs or builds must conform to rigid limitations. It must not take up valuable stage space, it must be practical, dependable and fool-proof and it must cost very little. The theatre technician's inspiration is seldom enough to evolve a workable piece of apparatus. While he is designing he will discover something he doesn't know, and he will rush to his physics professor for aid. He will have to borrow laboratory apparatus and run experiments in various laboratories. His stress calculations will have to be checked, the odd behavior of an intricate electrical circuit will have to be explained. He will labor in the chemistry laboratory to find out why his paint changed color

or how to make a smoke curtain. He will be forever building things in the machine shop, and if something is not done about him, he will wear out the whole faculty, and incidentally learn a lot of engineering. The engineering student in the theatre doesn't do his technical work for a grade in a course. The work has to be right, the device has to work. If he can't make it, the theatre will give the job to someone who can, and the unsuccessful student goes back to sweeping stage.

The value of the theatre in the engineering college can not be measured in facts learned, attitudes of mind and methods of approach to a subject, important as those are. There are fundamental accomplishments which must be the property of every educated man: grace, diction and manners, which the theatre may improve if they exist already in the individual, and teach if they do not exist. To be a convincing gentleman on the stage it is essential to be one on the street and in the locker room. To walk and stand with grace and ease, and speak the language free from provincial accent and without swallowing the final consonant are social graces, and what appeals more to the embryo engineer, economic assets. The theatre is a jealous mistress. The student player will play his part a hunded times in his mind for every rehearsal or performance. Thought and behavior patterns thus established are not destroyed when the curtain falls.

The aim of all education is to make men, to equip the fledgeling with that which the Romans called virtus. Any enterprise in which a group of people work and sacrifice toward a common end fosters virtus. Any endeavor in which an individual will drive his brain and his body, alone and for long periods of time, for love of his art, and with the hope of no reward other than the satisfaction of a task well done will make a man. The theatre is of its very nature such an enterprise. When a student has swept the stage and built a set, and torn it apart and built it over because it was inadequate as an expression of an idea, and strung cable, and played a part and re-orchestrated a score overnight because of a last minute cast change, when he will play the lead in one production and be prompter on the next with equal enthusiasm, then he has those virtues so highly prized in twentieth century civilization: courage, loyalty and a sense of the dignity of work.

OBJECTIVES AND METHODS OF TRAINING IN CIVIL ENGINEERING *

By H. S. ROGERS †

President, Polytechnic Institute of Brooklyn

The objectives of training which may be included in the preparation of civil engineers are so manifold and complex that I presume it would be futile to try to include all of them, great and small, in a general discussion which might be presented here. It is also a fair presumption that no two engineers would outline the objectives in a similar manner because no two experiences would lead to the same interpretations and judgments. Objectives of training in civil engineering are most frequently presented in terms of subject matter fields. They may, however, likewise be presented in terms of intellectual powers and habits to be developed by the student. In this paper I shall attempt to present a more or less general but unified analysis of those fundamental objectives, in terms of student mastery and understanding, which are more universally recognized in the engineer's training and which are of primary interest to the classroom teacher because of their relationship to an effective methodology of instruction.

There are at least three general objectives in the training of an engineer. They are: a mastery of those principles and practices which characterize the differentiated fields of engineering; a discipline in those ideals, attitudes, habits and skills which are distinctive of engineering thought and work; and the development of a cultural and economic background from which the engineer may understandingly find his own position in relation to society and its problems and build a philosophy of life. All three of these have been variously recognized in our educational program. The objectives of mastery have been rather specifically defined in terms of subject matter field, but not often have they been expressed in terms of concepts and powers to be developed by the student. The objectives of discipline have been less directly pursued, yet they are more or less inherent in all engineering training. Engineering curricula have required such rigorous and industrious work that certain attitudes and habits have been established during their pursuit. Efficiency, economy, and conservation are characteristic

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† Chairman of the Educational Policies and Teaching Methods Committee in the Civil Engineering Division of the Society.

of engineering study and accuracy, thoroughness, and neatness are traditionally required in all forms of engineering training. While objectives of mastery and discipline have been followed in a general way, no comprehensive, unified, and valid philosophy of engineering training has been formulated.

The development of a cultural and economic background has been necessarily limited in scope and varied in nature. When one surveys the tremendous amount of learning outside the field of engineering thought which might be of interest and value to the engineer, it is of course readily apparent that he can hardly hope to be even introduced to much of it within his period of undergraduate training. Engineering curricula have therefore limited their selection in collateral fields to a few of the more necessary and universally applicable subjects such as English, History, and Economics. I presume we shall always be disappointed in the limited education which can be provided in these collateral fields.

Objectives of Mastery

All of the courses in the technical division of engineering curricula may be classified in a general way under four categories. First, those in which the objectives are concerned with the mastery of basic principles and in which the development of a critical understanding of such principles predominates may be called basic courses. Such, for example, are Mechanics and Hydraulics. Another group are those courses which emphasize the derivation and use of standard methods of applying principles to more or less standard problems. Characteristic of these are Structural Design and Electrical Power Transmission. A third group are those courses which have for their principal purpose the presenting of information upon standard practice and current methods of construction or application. Under this heading are found such courses as Water Supply, as usually taught, and Power Plant Engineering. Neither of these can be said, however, to be solely and exclusively informational. A fourth group are these courses which have for their objectives the development of manipulated skills, such as Drawing or Surveying. It, of course, will be immediately clear that no one course is exclusively basic, applied, informational. or manipulative. Each course combines at least some of all of these characteristics. In general, however, courses are characterized by their predominate emphasis upon one or another of these objectives.

Problems of Basic Courses

The major purpose of basic courses is the mastery of the principles around which they are organized and which are construc-

tively used in the solution of engineering problems. These principles may be of a rational and generic nature such as the laws of equilibrium, of an empirical nature such as the ultimate strengths of materials, or of a hypothetical nature as the stress-strain relationships in beams under flexure. The physical concepts upon which principles are based are frequently so obscure in textbooks that students follow algebraic methods of derivation rather than seek critical understanding. This may be true, for example, in such subjects as internal shear in beams, and flows through submerged weirs. Textbooks are generally written for the clear presentation of concepts in rigorous mathematical terms and this sometimes obscures physical relationships.

The free-body sketch and graphical methods are universally used in presenting the physical concepts underlying abstract analyses. We can go still farther with the development of such concepts as solids of pressure, of stress, or flow which can be used in the mastery of physical concepts.

Empirical principles, of course, are best studied in the laboratory. They should be clearly differentiated from hypotheses and generic principles. Hypotheses need, of course, to be studied both in the abstract and in the laboratory demonstration. Most of them are very definitely limited in their application and it is important that students understand these limitations.

The method of presenting these principles in basic courses of the civil engineering curriculum is a field of interest which might well occupy the attention of any educational committee in the Civil Engineering Division for some time.

Applied Courses

The major purpose of applied courses is the development of facility in the use of general purpose tools. The true mastery of such tools is of course based upon a recognition of the physical concepts involved and of their generic nature. The objective of developing facility in the use of methods calls for rather intensive drill, such as in Structural Analysis. Although the major emphasis may be placed upon method, this should not be at the expense of the recognition of underlying principles and of the processes through which working tools have been derived. Students are prone to follow method without critical understanding of underlying principles. It is not an uncommon thing for an instructor to emphasize principles and to have many in the class only grasp the particular method. A comparative study of the pedagogy in those courses built primarily upon derived methods of solving design problems should be of great interest.

Informational Courses

The purpose of informational courses is to develop a knowledge of standard practices and certain forms of construction and application. There is little room for strictly informational courses in any engineering curriculum and very few courses of this type find their way into the engineer's training. Informational elements are in general combined to some extent in basic courses and perhaps to a greater extent in applied courses, but such courses as Water Supply and Power Plant Engineering, as usually taught, are more particularly presented as informational courses.

Where the object is to give the student more or less complete and accurate information upon practice, certain types of instruction seem most effective. One may assign several chapters and talk for several periods upon filtration plants and do less in giving a student understanding of the subject than can be done by a two hour inspection trip to some plant. Slides and films are particularly helpful in informational courses. Libraries of plans may be used to great advantage in presenting comparative types of construction. If informational courses are to bring a real benefit to students, instructors in them must be in immediate and active touch with the fields which they present and must exercise ingenuity in the presentation of these fields to students.

Manipulative Courses

Manipulative courses such as drawing, surveying and certain laboratory courses are characterized by emphasis upon drill in operation and the important objective is the development of facility or skill. In drawing and in surveying, practices for teaching manipulative courses have been very well developed and are more or less in harmony with psychologically determined methods. In general, college courses involve, however, other elements than manipulation. Certain concepts of principle, certain critical understanding of method, certain matters of information are embodied in each of them. A combination of classroom discussions, practice periods and written exercises can be combined rather effectively even in the teaching of drawing as well as in the teaching of surveying. It would be interesting for the drawing division to make a study of the application of the examination method to the teaching of drawing.

Objectives of Discipline

The objectives of discipline belong to no particular courses. While the objectives of mastery are specific in kind for each course,

the objectives of discipline are general and should characterize every course. Industry, accuracy, thoroughness, neatness, straight line thinking, habits of effective work and expression, should be among the objectives of all classroom work and their development among the responsibilities of each instructor. Discipline in general results from the instructional methods followed. It is not uncommon, for example, to find boys doing neat and accurate work in one course and slovenly and careless work in another which they simultaneously pursue. The type of work done by the average student is determined by the establishment of class standards and by the limit of tolerance which the instructor applies. High standards of performance should be demanded and held in (1) all forms of expression, written, oral, and graphic, (2) in ideals of industry, accuracy, thoroughness, neatness, promptitude, et-cetera, (3) and standards of clarity and directness of thought. The instructor who accepts slovenly and disorderly algebraic work under the assumption that it is his responsibility to teach only the principles underlying such work ignores the larger responsibility of developing engineers. The instructor who accepts laboratory reports characterized by poor organization and faulty construction is likewise neglecting the responsibility of training engineers.

It is impossible to lay too much emphasis upon the coördination of these objectives of discipline with those of mastery. The accumulation of information even of a fundamental nature will not produce graduates with power required for advancement in the profession, but intellectual mastery complemented by four years of rigorous discipline in high ideals of work and expression will do much toward advancing the opportunities of graduates and improving the status of the engineering profession.

Objectives of Cultural and Economic Background

The objectives of developing a cultural and economic background in the four years of an engineer's academic training are limited by time and the requirements of his technical training. The development of any curricula is a matter of selecting not what is desirable but what is most desirable and subjects for inclusion in a curriculum are chosen not because of absolute value but because of their relative value. In general, after adequate time has been allowed for the development of engineering sequences, little is left for the broadening of the student's mind by work in collateral courses. Among collateral courses English is most often included as a tool course for the development of effective expression. Economics and other courses in social science are likewise selected for an understanding of the world. Few cultural courses

in the fields of fine arts, of English literature, or of philosophy are ever included. In recent years there has been a changing emphasis upon the cultural phase of the engineer's training and the current economic conditions are accenting the necessity for a broader social view and a deeper comprehension of social and economic forces and problems.

Conclusion

The objectives of mastery, whether they be of generic principles, of methods or of information, are particularly the responsibility of the classroom teacher, but they should not overshadow the objectives of discipline. Discipline in developing the habits, attitudes, skills and powers which characterize engineering is equally a responsibility of the classroom. Permanent results of discipline can be attained only through the development of high ideals and the holding of high standards. The development of cultural and economic background is determined in no small degree by the design of the curriculum. The distribution of collateral studies is comparable to the spread of interest required in liberal arts elections and reminds one of the latter phrase in that old axiom that an educated man must know everything of something and something of everything.

There are in addition to the objectives discussed in this paper still broader objectives which become the responsibility of various functional services throughout an institution and of various divisions of the administration. All have their particular place in the pattern of higher education. Some are of a more specific and others of a more intangible nature. Objectives of this type are not, however, the direct responsibility of the instructor in the classroom although they may be a bi-product of his personal influence.

There is throughout our engineering schools a need for a better understanding of the philosophy of engineering education and for a more critical approach in its study. Engineers have been so busily occupied with the development of the fields of engineering science and of practice in them that little time has been given for consideration of philosophy and methods of training. I am not one who feels that a critical study of purpose and of pedagogy will greatly upset our present classroom practices. I do feel, however, that such a study will bring the classroom teachers closer together. will give them a more critical understanding of each other's work, and will stimulate the spirit of engineering education by no mean and immeasurable degree. Here is truly a great piece of work for the Civil Engineering Division to undertake.

THE AIMS AND TECHNIQUES OF TEACHING*

By F. A. MAGOUN

Associate Professor of Humanics, Massachusetts Institute of Technology

"Education is a system of habits for worth-while growth." So, at least, goes the definition adopted by a group of faculty members of the Massachusetts Institute of Technology who were actively interested in the Aims and Techniques of Teaching.†

It is the opinion of the group that where there is no continuing growth there may have been schooling but there cannot be education. When growth stops, death begins; be it physical or mental.

Not just college, but all of life is thus a process of education and the task of the teacher is less than half done when he merely acquaints the student with a body of facts. One does not learn to swim by listening to lectures on the viscosity of water, the effect of obliquely applied forces, and the articulation of the shoulder blade. Learning, to be virile, must be used, and the adequate teacher is more anxious to give his students a grasp of good method, than just a knowledge of many facts. As Elliott Dunlop Smith expresses it, "The student must learn to think for himself, not just to remember what somebody else thought."

If then, education is a system of habits for worth-while growth, there follow four questions, the answers to which—by any standard that makes sense—must be fundamental to the aims and techniques of teaching.

(1) What is a habit?
(2) What are the basic habit patterns which characterize an educated man?
(3) How can he be given these habits?
(4) What tests will show when he has acquired them?

Only a recognized psychologist would be competent to answer the first question, but within the limits of our ability to understand the work of such men as James, Freud, Watson, and Dewey,

* Presented, October 19, 1935, at the meeting of the New England Section, S. P. E. E.

† R. G. Adams, Mechanical Eng.; A. R. Davis, Chemistry; R. D. Douglass, Math.; J. W. Horton, Elect. Eng.; F. K. Morris, Geology; K. C. Reynolds, Civil Eng.; T. K. Sherwood, Chem. Eng.; R. H. Smith, Aeronautics; J. A. Stratton, Physics; G. W. Swett, Mech. Eng.; W. C. Voss, Building Construction; F. A. Magoun, Humanics, Chairman.

a habit is an acquired pattern of action or of thinking which can be repeated without conscious attention to the means, but only to the end desired. It is a time saving organization which is not just a tool, but an active means to a desired end. We walk, unconscious of our freedom from the labored concentration on locomotion itself necessary to the two year old, because we desire to go to a particular place.

What then, are the acquired patterns of action or thinking which are so completely a part of the truly educated man as to be habitual? In short, what is the end result we as teachers are seeking, and can we see it as a whole? The problem of examining education has too often been approached in terms of "less English and more calculus," or something to that effect. This is to keep one's nose so close to the canvas as not to see the picture at all, and the results are exactly like those of the myopic gentleman who looked at an inverted jar, saying, "Why this has no mouth." Then, turning it over he continued, "And the bottom is gone too!"

After months of discussion during which the Committee lingered with furrowed brow over many a debatable point, we submit the accompanying outline of what seem to us to be the basic habit patterns of an educated man:

I. *Body*
- (*A*) Habits of controlled appetites
  - (1) food
    - (*a*) type
    - (*b*) amount
    - (*c*) regularity
  - (2) drink
    - (*a*) type
    - (*b*) amount
    - (*c*) regularity
  - (3) sex
    - (*a*) type
    - (*b*) amount
    - (*c*) regularity
- (*B*) Habits of proper cleansing
  - (1) internal
    - (*a*) type
    - (*b*) amount
    - (*c*) regularity
  - (2) external
    - (*a*) type
    - (*b*) amount
    - (*c*) regularity

(*C*) Habits of proper exercise and posture
(1) type
(2) amount
(3) regularity
(*D*) Habits of proper sleep
(1) type
(2) amount
(3) regularity
(*E*) Habits of correct dress
(1) style
(2) amount

II. *Intellect*
(*A*) Habits of observation
(1) adequate
(2) accurate
(*B*) Habits of using available data and technique
(1) traditional
(2) recent
(*C*) Habits of discrimination and unbiased judgment
(1) appreciation of truth
(*a*) in time-worn experience
1. factual
2. artistic
3. moral
(b) in new experience
1. factual
2. artistic
3. moral
(2) sense of proportion
(*a*) evaluation
(*b*) tolerance
(*c*) humor
(*D*) Habits of independent thought
(1) Thinking in sequences by integration of primary data (correlation)
(*a*) logically
(*b*) penetratively
(*c*) selectively by weighing:
1. objectivity
2. reliability
3. validity
(2) Integrating conclusions of sequential thinking (judgment)
(*a*) perceiving relationships
(*b*) weighing evidence

(3) Analytical extrapolation of data and conclusions to projecting problems and predicting results (vision)

(*E*) Habits of substantiating all conclusions

III. *Personality*

(*A*) Habits of evolving and discriminating desires

(1) Growth measured by

(*a*) direction

(*b*) distance

(*B*) Habits of evolving standards (self-criticism)

(1) Based on accepted truth

(2) Allowing for constructive growth

(3) Tested by comparison with great personalities

(*C*) Habits of self-restraint

(1) Emotional stability

(2) Integrity (ability to adhere to standards)

(*D*) Habits of self-direction

(1) Persistence

(2) Initiative

(*E*) Habits of desirable associations with people

(1) Individually

(*a*) impact

consideration for others—sympathetic understanding

savoir faire

evidence of reliability

(*b*) response

coöperation

sympathetic understanding

(2) Collectively

(*a*) impact

(*b*) response

(3) Vicariously

(*a*) impact

(*b*) response

Unfortunately words are not an exact language like mathematics or music or mechanical drawing. Consequently the outline will not imply the same things to everyone else that it has come to mean to us as a result of our evolving interpretation. We intend, for example, that "Habits of discrimination and unbiased judgment" shall cover whom to believe as well as what to believe. As a sub-topic under this item the appreciation of artistic truth is intended to imply that the technical man cannot consider himself truly educated merely because he has mastered factual or scientific

truth. He must also appreciate (he will obviously not understand exhaustively even though he be a Leonardo da Vinci), painting, music, poetry, literature, drama, philosophy and the like.

There are undoubtedly some who feel that the faculty should concern themselves only with the curriculum; that the student's physique and his personality are no proper affair of the professor. But education is for the whole man. Of what use is it to train a fine mind in physics if the man's emotions are so mal-adjusted that he is drunk half the time? "The educated man does not ignore or repress his emotions; he learns to understand and to control them." Furthermore, such understanding and control is far more important than a grasp of the continuous beam formula, of colloidal chemistry, or of the theory of least squares.

Right here is the reason industry does not write the college, "Send us four men whose grades were B or above." The employer wants to see the WHOLE man; to appraise the long-time things like persistence, integrity, imagination, coöperativeness. "We are responsible for the goods but not the customer," may still be a satisfactory slogan for the department stores but not for the colleges. The college exists for the sake of the customer.

In the past we have concentrated far too much on the MEANS of teaching with too little attention to that most important factor, its PURPOSE. We have tried to teach the subject instead of the student, which is ample explanation for the fact that of 4,100 students graduating from Pennsylvania Colleges in 1928 the Carnegie Foundation for the Advancement of teaching found that 58 per cent of them saw in extra curricular activities (both intellectual and non-intellectual) the values in college which were of the greatest permanent worth to them.*

Having defined, with almost unanimous agreement, what we consider the basic habits of an educated man, the next step was to discover how the student could be led into the development of these habits. Does the material and its treatment as offered by our educational institutions result in the acquiring of these habits? What changes should be made to produce the desired end? On this point the Committee has been frankly bewildered again and again by a discouraging and uninspired fog. But there are certain general principles concerning the acquiring of habits—again interpreting the psychologists to the best of our ability—which constitute the solid ground from which we are attempting to leap.

* W. S. Learned: "Testing for Values in Education," *Bulletin of the Association of American Colleges*, Volume XX, No. 1, March, 1934.

Habit Formation *

Aptitude + Proper Nourishment + Proper Exercise = Correct Habit

Aptitude

(1) Constant for any given individual
Selection of raw material must be right

Proper Nourishment

(1) Must be appropriate to kind and amount of exercise
(2) Must create desire, or at least no active opposition
Mere repetition (exercise) not enough
Objective progress or strong hope of success essential, interest cannot long survive frustration
(*a*) Desire determines:
Nature of final development
Depth of drive
(*b*) Desire a function of intensity, not duration of experience
(3) Desires must be harmonious
Otherwise a weak vacillating character results

Proper Exercise

(1) Cannot be long separated from nourishment
(2) Initial pattern should lead logically to final skill
Nothing to unlearn
(3) Pattern must always be complete
Cannot learn parts and combine
(4) Pattern should constantly be checked against standards
Even after habit is well formed

The first requisite is obviously aptitude. To quote a personal letter from the educational director of one of America's largest industrial firms, "I have seen so many young men come into industry with practically nothing and make good, by adjusting themselves quickly to situations, that I have come to believe that the educational process doesn't have as much bearing on the subject as the heredity endowment of the individual. The thing we call intelligence is after all the fundamental."

We know of no reliable test yet available for any but physical aptitudes, but the same succession of patient researches which over the years changed the asthmatic atmospheric engine into a power-

* The equation is based on a quite similar expression devised by Arthur Frederick Sheldon. Much of the outline has resulted from a study of such books as "Psychology for Executives," E. D. Smith; "Habit," William James; "Human Nature and Conduct," John Dewey.

ful turbine will unquestionably give us reliable intelligence and temperament test in the not too distant future. Our responsibility is to assist coöperatively in the realization of this goal; not to retard its coming by scoffing.

That we cannot yet measure, let us say engineering aptitude, with certainty, makes no less important the physical, mental, and temperamental characteristics which the student brings with him. Some characteristics cannot be changed because their period of development is over at the college age. Others can. "Less emphasis in the schools should be laid on obtaining high marks in abstract studies and more on fitting the individual for his life work, taking into account his inherent temperamental and mental peculiarities and limitations. This will require a certain amount of individual work on the part of the instructors which may not fit in well with the present American method of mass production of technical school graduates."*

Our habit equation makes it obvious that the habit must have both proper exercise and proper nourishment. It were as silly to expect the track coach to develop a winning team by carefully supervising their diet while keeping them supinely in bed, as to expect a teacher to educate a man merely by stuffing his ears with carefully selected lectures. And the *student himself* must do the exercising; he cannot become an intellectual distance runner by driving around the educational track in an automobile. There is no royal road to either athletic laurels or to wisdom.

To be sure, thinking cannot proceed without a body of knowledge to think about. Nevertheless, the body of knowledge (memorized facts) without the thinking (awareness of relationships which the mind establishes by abstraction and generalization) is like an unorganized pile of building materials: not a structure, but a potential dump heap. No one would suggest a college where students just thought (exercise) without any material to think about (nourishment), and the reverse is just as absurd. Thinking is a constructional process. To furnish the materials and then to stop there is rank deception. It makes the student think he has understanding when all he has is facts. It is as though he had a violin without the least knowledge of how to play it.

Much of our teaching technique is to glut the student's mind with a great tonnage of information perhaps to deny him any real opportunity for the exercise of leisurely reflection; almost certainly to neglect giving him any stimulus to such reflection. The child's burning desire to explore things for himself has been sac-

* Spooner, Thomas, Fellow A. I. E. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.; "Characteristics of a Group of Engineers," *Electrical Engineering*, December, 1934.

rificed on the altar of credit hours. Curiosity has been smothered and the intellectual appetite destroyed because the professor has answered questions before the students' instinct for investigating ever had a chance to become hungry for the answer.

Under these circumstances how can there be any system of habits for growth? Socrates did not hand out information. By the simple technique of leading the student in quest for knowledge he made himself one of the very greatest teachers of all time. The really important thing in the "nourishment" part of formal education is the attitude of the faculty toward what constitutes an education. It is of no avail whatsoever to increase the number of hours devoted to English Composition unless the body of faculty opinion really believes the ability to write is important. The students are much more accurate in their estimate of what a professor wants than he is himself, and they try to give him what he wants. They grow in accordance with the sort of nourishment they are given: i.e., what gets the rewards they want. When the faculty place emphasis on thinking as well as on remembering, so will the students. The teacher tends to do the easy thing just as much as the pupil does. It is easy to teach facts to be remembered and extremely difficult to devise methods of teaching which compel the student to think about these facts.

We submit that any class in which there is a considerable uniformity in the notes taken, is largely a class in remembering, not in thinking.

Given aptitude, the desired habit must be properly nourished (not satiated), properly exercised (not coddled), and the exercise cannot long lag behind the nourishment. It is futile to give a student instruction today which he is expected to put into operation for the first time next term.

"But the student must have a background of fundamental knowledge before he can use the knowledge to think for himself," say some of us. "He can never use a thing intelligently until he understands it." To be consistent, these gentlemen should never cross a bridge they could not design, nor drive an automobile until they have mastered such mysteries as epicycle trains, carburetors, and the properties of alloy steels.

Others of us feel that the background is achieved as a part of the thinking, exactly as a child learns his native language. He does not first learn his vocabulary and then begin to use it; he learns his vocabulary by using it. Our point has been illustrated by someone else who took two groups of adult pupils who were given a complicated multiplication table to learn, as for instance 35×43. One group applied themselves to memorizing it before using it. The second used it at once and learned by using with-

out any conscious attempt to memorize. This group used the table more accurately and with less effort than the first group.

This is the method of learning most likely to stimulate the students' interest and, as we have seen, desire is a very potent factor in acquiring habits. "For getting a fine flourishing growth of stupidity there is nothing like pouring out on a mind a good amount of subjects in which it feels no interest," says George Eliot in "The Mill on The Floss." She might have added some cogent words about the crime of killing interest by poor teaching technique.

In order for the student to be interested he must feel that the subject is worth-while—not merely academic. He must be able to see that he is making progress, or at least have an active faith that he will soon do so. What kind of progress and how far it goes depends upon the depth of the drive behind the desire. Few men in any century have the unquenchable longing to know which compelled Abraham Lincoln to keep on asking questions despite the fact that his father often knocked him flat for so doing.

Because the intensity of an experience has more effect than its mere repetition, we believe that good teaching is largely a matter of emphasis. A very common error for the beginner in differential calculus is omitting to add du/dx. To give emphasis to the necessity of including the term, let the instructor first write the equation:

$$\frac{d}{dx}u^n = nu^{n-1}\frac{du}{dx}.$$

Then in the next problem, let him deliberately leave off the du/dx. The class rises in a body. They have been impressed by the intensity of the experience in two ways, and also have been given an opportunity to demonstrate to themselves their own progress in the calculus.

The first requirement of properly exercising a habit is that the beginner's pattern should lead logically to the final skill desired. Certainly in a college man we desire habits of independent, penetrating discrimination, based on adequate, accurate observation and use of available knowledge. Then why not give exercise to such thinking? Take, for example, that tricky pitfall of units. Ask the student what one plus one equals. Then ask him what one cat plus one mouse equals, or what one rabbit plus one rabbit equals. If 2 feet times 2 feet are 4 square feet, how much are 2 cows times 2 cows? Studying a problem like that will reveal how we have buried reasoning in our conventions. It is not 2 feet times 2 feet at all but two times a row of two square feet in each

row. When he gets to studying optics ask him if the right hand of the mirrored image is where the left hand should be, why are not the legs where the head is?

Simple things, these, but they make the student reflect, and such exercise results in a real grasp of the subject, because he gets the exact significance of both the units and the processes he is dealing with.

Habits of judgment are not well developed in college because we seldom ask the student to exercise his judgment. Almost every problem is presented with exactly the data necessary for solution and no more. Life never prepares our problems for us. We have to find out which data, of the available mass, are relevant and what obscure items are essential. Why not habitually give problems containing at least twice as much data as needed and occasionally one that cannot be solved unless the student appeals to the professor for additional information.

In place of so much routine problem solving, the student should be given more METHOD solving. By this we mean exercise in explaining with great exactness *how* he would do the problem instead of fitting data into a formula and reaching for a slide rule. The best minds on our faculty seem to approach a new problem by saying, "I can get such-and-such a value by doing this, then I can find so-and-so that way; and from the two can be found . . .," etc. These intellects do not actually perform the work, but merely lay out an exact route to the answer much as a suburban mother would think through the route by which her small son was to do errand in the city—weighing factors of time, expense, traffic, and directness.

If this is to be the final skill, then it ought also to be the initial pattern. It is our understanding that Dean Dougherty of the Sheffield Scientific School has done exactly this sort of teaching with magnificent results.

Our Committee also makes an urgent plea for more inductive reasoning instead of so much practice in deduction. The great thinking of Archimedes about the tub, Newton and the apple, Franklin and the kite was not deduction. Let us exercise that flash of insight, which is inductive, by turning the student loose on his own. What if he doesn't cover as much ground? Which is better: to have a large quantity of right answers through bottle-fed mental processes or cover a much smaller amount of ground through absolutely correct methods of habit growth?

Why it is so difficult to convince the ordinary man that the parts of a habit cannot be learned separately and then combined, is a mystery. Let the skeptic try the following simple demonstration of the inefficacy of separateness: with the right index finger tap

out sixteenth notes on the desk top until it can be done with regularity. Easy! Now with the left index finger beat triplets. Easy! All right, now do both of them at once; one finger beating three while the other beats four. Impossible! But the pianist, who has *learned the two together,* can do it.

By the same sign, the student cannot be taught a lot of facts now and how to use them by and by. He cannot think math as math this term, and math as physics next year. Nor can facts be learned at one time and the art of thinking about them, at another. True learning is the establishing of relationships between new material and what we already know and the accent should be on *relationships.*

Last of all, the excellence of any habit depends upon the standard by which its development is measured. The initial pattern is always wrong, as for example a youngster trying to play a Bach fugue. But the desire to play good music, together with standards of what constitutes virtuosity (both stimulated, let us not forget, only by actually hearing good music—good in composition and good in rendition), makes more and more successful, repeated attempts to play a difficult passage. Practice makes perfect only insofar as the standard desired and consistently striven for is perfect.

We said education was a system of habits for worth-while growth; not just a system of habits, not just ruts, but worth-while growth which lasts as long as life itself.

CONFERENCE ON PHYSICS *

The Physics Conference of the Forty-Third Annual Meeting of the Society for the Promotion of Engineering Education was held in the Physics Building of Georgia School of Technology on June 24th and 25th. A group interested in the teaching problems confronting those teaching Physics to engineering students, attended and entered into the discussions. The average attendance was twenty-five. Each paper in the program brought out a lively discussion and swap of teaching experiences. A social hour with a special luncheon was arranged for by the Georgia Tech. members of this group and proved to be a very enjoyable event.

Before adjournment it was voted unanimously that the conference had been a success and that it was the opinion of this group that S. P. E. E. should continue to foster such conferences.

The program was as follows:

MONDAY, JUNE 24

Physics Texts for Engineering Students. E. E. Bortell, Georgia School of Technology.

Most Efficient Use of Time Spent in the Laboratory. Percy Hodge, Stevens Institute of Technology. (Read by the chairman.)

The Physics Laboratory Report for Engineering Students. G. E. Grantham, Cornell University.

TUESDAY, JUNE 25

Use of the Computation Section. D. M. Bennett, University of Louisville.

Physics the Engineer Should Know. O. W. Eshbach, American Tel. and Tel. Co.

Aims and Objectives of Physics Teaching in Engineering Colleges. D. S. Elliott, Tulane University.

G. E. GRANTHAM, *Chairman.*

AIMS AND OBJECTIVES OF PHYSICS IN AN ENGINEERING SCHOOL

BY DANIEL S. ELLIOTT

Professor of Physics, Tulane University

This paper is intended to be provocative. It is inspired by the idea that although fairly satisfactory progress may be made from day to day by dead reckoning, nevertheless, it is highly desirable

* Papers presented at Atlanta Meeting, S. P. E. E., June 24–27, 1935.

from time to time to check up on our navigation instruments by shooting the stars. As H. W. Farwell has put it, every teacher of physics ought to answer, at not too long intervals, these two questions: What do I think I am doing? and, secondly, What am I really doing? To which I add a third: What should I try to do?

It might help to clear matters by stating once for all that the teacher of physics in an engineering school should not expect to convert his students into "professional physicists." Rather, he should always, at least remotely, remember that his aims and objectives are inseparably tied up with the aims and objectives of engineering. Let us stop for a moment to see what some of the leaders in the profession have to say on this point. We quote copiously from Karapetoff, Potter and Jackson.

In an article entitled "Engineering Schools and the Change of Conditions" Karapetoff says: "An analytical scholarly faculty is the key," instruction must change to emphasis on "a thorough knowledge of the fundamental and inspired leadership in definite trends of the human mind." Karapetoff's main thesis is this: New leadership in engineering must be faced with a profound scholarship; with a call for fearless analysis of the fundamental and technical; and with an appeal for creative work in new paths. "After almost everything has been tried to circumvent it, there must be a return to the straight, narrow academic path which leads back into the fundamental laws of nature, including those of the mind."

In his article entitled "Trends in Engineering Education," Dean A. A. Potter defines "the main objective of engineering education as the preparation for successful living in a scientific age and points out that whether people like it or not, they are destined to live and work in an environment which is being affected more and more by science and engineering. Thus the study of science and its application to engineering must be considered as the best type of preparation for successful living in our present civilization." Dean Potter continues, "The achievements of the engineering profession of to-morrow can only be kept at a high level by new scientific knowledge. The engineer of to-day is constantly using more and more scientific knowledge, while physicists and chemists are becoming interested in an increasing degree in the engineering applications of science. Thus, science and engineering are absolutely interdependent and the future progress of one depends on the other." Dean Potter thinks that, "In order to meet increased competition for positions of responsibility, the graduate of the future will have to be more prepared in the fundamental sciences; be able to express himself more clearly and correctly, and have a better appreciation of economic forces and social values. The grad-

uate must realize that the main objective of engineering education is the preparation for successful living in a scientific age."

And D. C. Jackson, in an article on the "Function of Research in Engineering Education," says "Elementary research is the exercise of the spirit of inquiry or scientific curiosity." It should be the object to saturate our students in an aura of resourceful reproductive thinking and doing. Even where the location and facilities are such as to preclude formal organization of research, this character of the work should be kept foremost in the minds of the teachers. If I interpret Professor Jackson correctly, his position reduces to this: We should develop resourceful planning and initiative by encouraging the development of the investigative spirit and resourcefulness even though we have to leave out some of the facts for the moment. "It is not a mental accumulation of facts alone that fits the engineer for his duties, but an understanding of the interrelations of facts and the methods of detecting and identifying facts."

So much for the background into which must fit our contributions as teachers of physics in engineering schools. Now let some of the physicists speak for their own objectives and aims.

Professor W. S. Franklin recognizes, as the main objective, "The teaching of precise ideas." In an article on the "Objectives of Undergraduate Courses in Physics" in 1928 Professor Franklin refers to two objectives. The first is the development of the integrating attitude of the mind, the ability to form pictures and to hold in mind broad concepts like the "kinetic theory," remembering that Helmholtz has said, "It is nevertheless a great help if we form in every case, the most concrete physical picture even though that picture contains many assumptions that are not in all strictness necessary;" Franklin's second point relates to the extent to which quantitative mathematics can be tied to physical conditions and things. Says he, "Every quantitative notion in physics is grown out of a precise idea. The teaching of precise ideas," Professor Franklin says, "is certainly the main objective of teaching physics in college and in the engineering school. And it holds for the preparation of young men for research even more rigorously than in preparation for practical work. Training in analytical thinking seems so all-important that nothing else need be mentioned in the consideration of the objectives of the teaching of physics." Franklin also points to the functional nature of definitions and principles in physics, and reminds us of Bacon's admonition to connect every detail of the analytical method with actual conditions and things. He concludes by emphasizing again his conviction that the only objective worth talking about in physics is training in analytical thinking.

In a challenging article on "Are we teaching Science?", D. H. Palmer asks, "Are we doing anything more than teaching a few fundamental facts and principles?" And he further asks whether it is not true that general acquisition of knowledge is of far less consequence than the inculcation of the scientific habit of thought. Palmer regards as most important the scientific point of view, namely, the critical survey of all ideas and generalizations, and is of the opinion that a person with a real scientific outlook will not only assimilate that which has been gleaned from a thoroughly experimental procedure, but at the same time will necessarily recognize his own prejudices, likes and dislikes, and make his judgments accordingly.

As you remember, quite a few years ago, the Educational Committee of the American Physical Society attempted, by the questionnaire method, to secure information on a number of points among which was this question: "What are we aiming at in Physics courses?" Heads of physics departments were asked to arrange the following aims in the order of their importance: (*a*) Scientific habits of thought; (*b*) Teaching the laws of Physics; (*c*) Facts and methods of Physics; (d) Accuracy of observation. Of the 89 answering, there was a great diversity of opinion.

Professor Arthur L. Foley of Indiana, in his paper on "The Goal of the Physics Teacher," goes even further. "Even though the majority of teachers agreed on certain objectives and certain methods, it is no indication of the infallibility of either objectives or methods. Certainly no excuse for forcing other teachers to adopt them." Foley reveals himself in the following paragraph: "All the outcomes of a course in physics do not come out during the school term, not even the school life. Benefits which one may receive from a study of physics are far too subtle to be measured in per cent; there is a body of knowledge which may be forgotten in a few months; but methods of thinking and habits and attitudes persist throughout life." Foley thinks one of the greatest requisites is for the student to be interested in what he is doing.

Professor Dearborn, in a paper before one of the Summer Sessions of the S. P. E. E., says that the student should learn to think for himself. "It is not sufficient that he should be able to follow in assent to a line of reasoning given by the teacher." He will have to do more than that in applying physics in industry and then the author wisely adds, "Teachers of engineering who have complained that students cannot bring any initiative to bear on their thinking about physical principles, often frankly admit that the same is true of the results in a subject which they themselves teach."

A consideration of the points already presented leads immediately, I believe, to the conviction that the subject is much too in-

volved to be handled like beads on a string. I am also of the opinion that engineering education should not be regarded as a series of horizontal strata, but rather as an intricate pattern to which the Physics Department makes its contribution as an essential part of the design running throughout the whole. Consequently, it seems to me that a better appreciation of the aims and objectives of a Physics Department in an Engineering School might be secured by a slightly different approach. Since we are dealing with growing individuals, studying a dynamic subject in an institution which must also reflect our changing civilization, does not this necessarily invite consideration of the following relationships?

(I) The relationship of the Physics Department to the individual student.
(II) The relationship of the Physics Department to the Engineering School at large and its objectives.
(III) The relationship of the department to the environment outside the engineering school.

These three, in turn, give rise to certain obligations which the department should endeavor to discharge faithfully.

I. Let us first consider the obligations to the student and let us consider him as raw material in the general course in physics. What has the student the right to expect from this course?

(*a*) First of all—the student should be given a precise vocabulary of physical terms and units, for this is the language in which he is to express ideas and assign numbers. This does not mean mere ability to repeat words but implies precise comprehension of the properties of the physical world referred to by these symbols, together with the concrete processes and criteria for their measurement and identification. It would be interesting to consider the methods by which this precise vocabulary is to be secured, and the scope of this vocabulary, but we limit ourselves to the following statement: We assume the scope to be that of classical physics, and something of what is known as modern physics. But most important in this connection, I think, is the early realization, on the part of the student, of the necessity for precision of vocabulary, so that in the future, from mere habit, his acquisition of new terms and units will have to run the self-imposed gauntlet of precision.

(*b*) Then, too, the course should give a spectrum of fundamental physical facts and physical relationships. And here, too, the problem takes on its first major requirement—for it calls for a growing acquaintance with physical facts and relationships. The problem becomes the problem of the growth of knowledge. As the major part of the problem is the learning of physics and not the teaching

of physics, the first course in physics should also contain advice and illustration of the way to study physics—probably definite advice in the early stages and less obvious instruction throughout the rest of the course—in a word, internal orientation of the student towards the course. The first step in this direction is the definite realization on the part of the student that the material for study is not localized in the textbook, but in the physical world about him; that through observation and experiment, clear and accurate ideas can be secured of the fundamental facts of this physical world and the relationship which exists between the various components of this physical world; that in order to understand from others and be understood by others, a precise vocabulary must be learned and used; that in the interest of the quantitative study of these relationships, the student must obtain a technique of symbolic representation as an economic and utilitarian device and as a basis for the definition of units of measurement and for arithmetical computations. Perhaps the hardest things for the student to comprehend is the limitations and the utilization of the symbolic shorthand of science as given by the formulas, all too often substituting mere memorization of letters without adequate ideas for the thoroughly comprehended physical relationships the symbols are supposed to represent; and while the student, of necessity, must acquire mathematical facility in manipulating these so-called formulas, the real training is in the recognition of the scope and limitation of the physical relationships behind the symbols.

(*c*) Another obligation to the student requires us to help him to comprehend those fundamental principles and generalizations which the integrating faculty of man has evolved through study of the more restricted physical relationship. The student should be encouraged to think in terms of principles and to develop skill in effecting a transition from the general principle to a specific application in the case of a problem. It should be enforced on the student that thinking by way of fundamental principles is the most economical approach for predicting the behavior of the physical world in a particular instance and as Maxwell has put it, for understanding "The go of it."

(*d*) The student must somehow be given an appreciation of the dynamical attitude concerning ideas. Gradually he must realize that however definite may be the physical world about us—man's present ideas of this physical world are the result of evolution. Occasional reference to those personalities who have been responsible for the unfolding and discovery of facts about nature create a feeling that these results are the findings of human beings like the student, and that our present physical ideas represent a continuous unfolding. This point of view will also promote a greater elasticity

of mind and readiness for future adjustment incident to the assimilation of the result of future researches which might cause modification of existing ideas.

(*e*) The department has an obligation to the student of engineering to help him acquire certain skills. Around the solution of problems, numerical, experimental or design, definite techniques, both mental and manipulative, should be suggested, if not definitely taught. Should these problems be given as models, the parallel to which point to similar problems in engineering? Probably there should be enough illustrative material from the engineering world to furnish a bridge of transition in the student's mind to prevent him from assuming that knowledge is of the compartment type, but it is our opinion that neither the problem section nor the laboratory should offer material for blind following; rather both should be handled in such a way as to give the student appreciation of (*a*) planning, (*b*) acquisition of definite technique, and (*c*) enlarged comprehension of the major physical principles of which the particular problem, apparatus, or experiment is merely one application among a host of known and unknown possibilities. Perhaps when the student meets his engineering, the emphasis should be shifted, but in physics the main emphasis should be the appreciation as well as the cultivation of planning, acquiring of special skills appropriated to the subject, and an enlarging comprehension of fundamental principles with a view to the utilization of these principles in unsuspected and undreamed—of engineering situations as well as those which have already been used as illustrative and stimulating material in the acquisition of present knowledge

(*f*) The department of physics has an obligation to distinguish the more gifted from the less gifted. After all, education is an individual problem—someone gets educated, and an obvious corrolary is the necessity for self-inspection in order to secure the maximum self-realization on the part of the student. Students are personalities with different ambitions, capacities, habits, and attitudes—students should be helped to a proper understanding of themselves. Do we take enough recognition of the differences between students—or do we place a premium upon the fast but perhaps superficial mind; do we increase rate of development of the individual; do we encourage the student to organize his own programs by having him work in an atmosphere which has been organized for coöperative work, but is still elastic enough for individual differences? Personally, I don't believe we can overlook this obligation.

To summarize then, here are some of the results which the student of freshman or sophomore physics has the right to expect:

1. Acquisition of proper methods, habits and proceedings for studying the subject.
2. An accurate vocabulary of terms, units, and ideas—particularly in what is generally known as classical physics.
3. Acquisition of techniques or special skills in the manipulation of ideas and physical equipment.
4. Comprehension of the fundamental principles in terms of which we describe the physical world, and reasonable ability to apply these in known and yet-to-be-discovered situations.
5. Appreciation of, and experience in, planning, organization, accuracy and coöperation.
6. An estimate of, or at least an awareness of, his own personal limitations, and general habits, attitudes and philosophy.
7. Critical attitude towards all knowledge.
8. Cultivation of interest and curiosity, leading to study and reflection initiated by himself.

II. What about the obligations of the Physics Department arising out of its relation to the college of engineering?

The physics department in a college of engineering must constantly maintain liaison with other departments of the college, and neither regard itself nor be regarded by other departments as an isolated and unintegrated part of the college of engineering. The main business of a physics department in a college of engineering is, after all, to make its contribution to that final product of the college—the engineering graduate, and this certainly can not be best realized by a policy of isolation. There should be sufficient familiarity with the work of other departments to offer a course of instruction which in scope and treatment, gives adequate preparation for those strictly engineering courses. But the obligation does not stop there, for engineering is a dynamic and changing proposition and not a static one.

There is an inseparable transition between discoveries in the physical sciences, their complete study, and in many cases the appropriation and application of those facts and principles to industry. This has happened so often that illustration would be superfluous. Hence, there arises the obligation on the physics department to see that this information is kept available. This suggests the supervision and maintenance of the accumulating literature both in the field of physics and also in those adjacent fields which represent the first movements from science to engineering. I am thinking particularly at the moment of the Proceedings of the Institute of Radio Engineers, Proceedings of the Acoustical Engineers, Proceedings of the Motion Picture Engineers, etc. Also certain skills peculiar to the interest and training of the physicist

should in limited amounts be available among the personnel of a well-organized physics department in a college of engineering. The department should hold itself ready for coöperative enterprises with engineering departments.

Several years ago, Arthur D. Little, in one of his bulletins, summarized one of the general obligations of a physics department by referring to what he called Physical Engineering. The particular tie-in between chemistry and engineering being called Chemical-Engineering—a corresponding tie-in between physics and engineering is what is meant by "physical engineering." To take care of this, no violent change in the present organization of the curriculum of the college of engineering is necessary, but rather a wider comprehension of the function of physics in the college of engineering; a more liberal opportunity for upper classmen to select electives in physics, together with the cultivation of a feeling that the material offered represents the raw material for appropriation into one or more of the main divisions of engineering of tomorrow. Some of us recall our somewhat surreptitious and apologetic attempts of a decade or more ago to cultivate a more appreciative attitude of our engineering students towards such phenomena as thermionics, photoelectricity. Still later we recall a similar experience with nuclear physics and the correlated problems in high voltage. There are many sets of special engineering problems whose solutions are based on either or both modern and classical physics but which are not included in the already too crowded engineering curriculum—these problems are the scope of physical engineering. The physics department should see that this training is available to the student without going outside of the college of engineering.

The department should also provide advanced courses to furnish sufficient number of electives for the student who desires a more extensive collateral training in science. As has been already said, there is an extensive body of knowledge which is at the half-way station between discovery and utilization, for which the physics department is the repository until such time as industry and engineering absorb it into one or several applications which become economic tools. Even where this has already taken place, there is need for advanced courses, having the account on principles and theory. It is true that the average engineering student may not be interested in such courses, but just the same they should be available to the unusual student whose interest lies in that direction.

It might, perhaps, be argued that the last two proposals are too ambitious and too elaborate for the cramped finances of the present, but it must at least be admitted that they rest on assumptions

which are valid: (1) engineering is a dynamic and not a static proposition since it deals with a civilization which is constantly changing; (2) many of the instrumentalities which are responsible for these changes are first met through physics and afterwards adapted and adopted to the world business; (3) in the interest of mental elasticity and in order that the student shall retain his respect for these coming changes, the physics department should be regarded as of equal importance with other major engineering departments, should be adequately financed, and should be encouraged in its own way and with its own peculiar facilities and point of view to make its contribution to the point of view and instructional development of the engineering graduate.

III. The third and the last set of obligations of the department of physics I call the extra curricular ones.

The obligations of the department of physics do not cease with its own students and the coöperation with the other departments of the college of engineering. The statement that there is a reciprocal influence between our civilization and scientific and engineering discoveries and adaptations, amounts to a truism. As an example, in a recent article, H. G. Wells, in discussing our present economic crisis, points to rapid communication and mass production as the two causes of our present social dilemma. There is need for further adult education along these lines. The physics department must assume its share of the responsibility to acquaint the local public with the results and possibilities of the output of the scientist and engineer. The community needs education along these lines—dignified, interesting education. Until this is undertaken as a definite and dignified responsibility, the engineer should not be surprised that the community does not get the significance of his contribution. Adequate financial support for the continuance and extension of his work will only follow where there is adequate appreciation of it. To bring this about, is, in part, the obligation of the physics department. The physics department should also, with tact, encourage science teaching in the high schools.

The final obligation of the department of physics is to promote research. Physical research should be encouraged and adequately financed for the following reasons: (1) The obligation to extend the bounds of knowledge as well as to conserve present findings rests on each one of us; (2) wisely guided research, even the most modestly prosecuted, produces in the minds of the teacher and student a more healthily skeptical attitude towards evidence and an accent on the evolving character of knowledge; (3) publication with attendance at regional and national meetings promotes both prestige for the institution and department as well as the easy interchange

of ideas. Research should be one of the accepted objectives of the physics department in a college of engineering.

The aims and objectives of a physics department in a college of engineering—what about the perspective? What about the possibilities of their realization? We leave the question of perspective to the individual departments, but the two outstanding sets of factors affecting the realization of the aims and objectives of the physics department are:

(1) The attitude of the administration as to aims and objectives of the physics department, as reflected in financial support which should be sufficient to enable the physics department to serve as an adjunct and preparation to the engineering studies proper, but, at the same time, to enable the department to make its additional contribution as a self-existent, independently contributing department of full rank, and

(2) The second set of factors will be the ingenuity and influence of the personalities of the department personnel, and their sustained interest in their students as developing personalities whose objectives are engineering ones, but whose training, habits, and attitudes are sufficiently elastic to enable them to adapt themselves to the engineering of to-morrow.

And so I end this paper as I started—the aim of this paper is provocative. I had hoped it might provoke comment and criticism. Perhaps its only value lies in the fact that it has led the author to a more critical examination of what he is trying to do himself.

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THE PHYSICS LABORATORY REPORT FOR THE ENGINEERING STUDENT

By G. E. GRANTHAM

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Teaching problems arising in specific fields are receiving more attention at present from members of the fields than formerly. This tendency to assume partial responsibility for the solution of problems in the field of Physisc instead of submitting them to the professional educationist is attested by the organization in 1932 of the American Association of Physics Teachers and this, the initial meeting of the Physics Conference of S. P. E. E. Combining the experience of the teacher of Physics with the valuable advice of the professional educationist on the learning process is, perhaps, a wise approach to the solution of such problems. For such a group as this to relate its experiences with various teaching problems is a step in this direction.

The laboratory report is one of the many problems confronting the teacher of courses of Physics in which there are large numbers of students. It is the thesis of this report to declare that a large amount of valuable time is wasted both by the student and the teacher by the requirement of formal reports on a large number of Physics experiments. By the formal report is meant the report of the type in which the subjects to be discussed are, in general, Object, Theory, Procedure, Computations, Results and Discussion. It is scarcely necessary to enumerate the vicious habits encouraged by this requirement—data are taken during the laboratory period, approved by an instructor who has little chance to teach during the period because, since the computed results are not attained, conclusions cannot be drawn. The student takes the data home where they are filed away until the night before the day the report must be submitted. Parts of the data have by this time lost their significance. He paraphrases the theory presented in the laboratory manual or worse yet copies it from an older report. If the equations are to be derived they may be copied from the manual or text with a changed notation. (A graduate student in Physics recently told me that during his undergraduate course in Physics he was constantly afraid he would be expelled from college because he was not adept in paraphrasing the words of the manual.) Who has not read report after report of this type? In writing such a report the student has learned little Physics and the teacher who conscientiously reads it wastes valuable time.

The average instructor in reading such reports soon recognizes the futility of doing much more than checking the results and read-

ing the conclusions. When the instructor next sees the student the data of another experiment are to be taken and usually there is little time for discussion.

A recent check on a class of over 200 engineering students gave the information that the outside time per student required for report writing was from 2.5 hrs. to 15 hrs. per week with an average of 6.75 hrs. It is to be admitted that this amount of time spent on a very limited number of reports written, for example, without reference to other material than the data, would be time well spent, but when the report is written, as it generally is written, and when from 30 to 60 such reports are required in a general physics course the waste of time is appalling.

It is not the purpose of this paper to elaborate on the evils of report writing without offering a substitute and the substitute is by no means original with the author.

It is proposed that, 15 minutes, an average amount of time spent in reading a report, spent by the instructor in discussing an experiment with the student during the time that the experiment is being performed and the results are being completed is worth far more to the elementary student than the 6.75 hrs. spent in paraphrasing the laboratory in preparation of the formal report. Such a proposal requires that most of the experiments be shortened so that time for the computations and the discussion would fall within that of the laboratory period. Under such a plan the student would view the experiment and results as a whole and not as two entirely separate problems. The experienced teacher recognizes that the last place to teach physics is in the laboratory and that this teaching, properly done, requires more painstaking effort and is more tiring than the teaching work of either the recitation or the lecture, but that the results attained are correspondingly more valuable. This proposal affords instruction not only during the time of the experiment but also during the computations and interpretations of results. The teacher can lead the student to answer his own questions and in turn propose other questions for the student, leading him to see the physical significance of his work.

The evils of the formal report as described above influenced us, in our freshman courses for engineering students at Cornell to do away with the formal report for these students. The student comes to the laboratory with a folder in which the experiment is outlined and the theory presented. This folder also contains a form for his data with the proper heading for columns. It is from this data form that he learns how to tabulate data in his sophomore work in which he designs his own data sheet. The student performs the experiment, making some of the computations as it progresses. His instructor is present to advise him and question him. Instruction

in the use of tables, slide rule, curve plotting, etc. is given. At the end of the work the student discusses his results with his instructor who then marks a grade on the folder which represents the rating of work of the whole period. The folder is subsequently returned to the student for review in connection with the examinations in the course.

In the sophomore year the student does 14 experiments and submits a formal report on each. No doubt many of the evils described above enter into the work of this report but the student has had a year's work in the laboratory and makes a more economical use of his time.

After three years experience with this plan the consensus of opinion is that further changes should result in reducing, rather than increasing, the number of formal reports required. Instructors report that the laboratory period is a real "work out" for them under the new plan but that they feel they are accomplishing something, a feeling which was absent in the hours spent in reading the formal report. It is the hope of the author that this report will bring out a discussion of the experience of others with this problem.

CONFERENCE ON THE TEACHING OF ENGINEERING ECONOMY *

TREATMENT OF THE COST ASPECTS OF ENGINEERING IN SCHOOL

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By "cost aspects of engineering" is meant that field of economics peculiarly that of the engineer in contrast to other fields belonging chiefly to the economist, accountant, banker, et cetera. This field embraces in particular the problems of economic selection and economic replacement. In addition estimating, valuation and the costing of materials, labor, services and their loadings or burdens, should be included. These problems are part and parcel of practically all engineering endeavor.

Engineering practice in industry is carried out in an atmosphere of cost considerations; although temporarily consigned to the background at times, no complete separation of cost aspects and technical aspects is possible. Reaching down even into research work the wedlock of the technical and the economic is largely unbroken. In contrast, the engineering school has always separated this happy couple and efforts to unite them are blocked by at least two very important considerations: (1) the lack of teachers imbued with the relative significance of costs in engineering, and (2) the impossibility of generating in the classroom a "pocketbook consciousness" from actual responsibility for financial consequences of engineering work.

Those who argue that the treatment of cost aspects belongs to the after-school period are in the main supported by the fact that no semblance of reality as generated by having actual responsibility for the economic factors, can be easily attained in the classroom. This much of their argument must be conceded. Other phases of their argument demanding deferment of cost considerations in engineering education because of the ease of obtaining information in these matters by post-school effort is subject to serious attack. Waiving consideration of all other answers to such arguments at this time, one cold fact should be exceedingly disturbing to the engineering educator. It is that *whatever the engi-*

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neer has to contribute to economic and social problems out of his engineering training and experience, must come out of his training in methods of engineering analysis of economic factors and in the marshalling of quantitative cost factors. It makes no difference whether the problem is presented to the engineer for consideration as an ordinary citizen or as a formal problem of industry. Looking this truth square in the face in the author's opinion places an unavoidable responsibility upon the engineering teacher to start such training early and give it an emphasis commensurate with its importance without vitiating the technical work.

The ideal teaching situation would involve the presentation of all technical theory in the same natural atmosphere of costs and economic considerations that surrounds engineering work in practice. It is believed by the author that an attempt to achieve such an ideal under present teaching conditions is just about futile because of the great contrast between classroom conditions and those in industry. The handling of cost aspects in the absence of responsibilities which make their meaning take life is a highly difficult job if the interest of the student is to be stimulated rather than depressed. The teacher whose own interest in these matters has never been truly stimulated by work of this nature outside the classroom in the very technical field in which he is teaching, is likely to be hostile to the idea and probably ineffective unless he gives great attention to matters of "interest-getting" and proper balance of such work in relation to the technical work. Even so the approach to the ideal situation is worth the struggle. It is the unnatural divorce of technical teaching from engineering economics that leads to many of the difficult adjustments required of the apprentice engineer in industry in developing his professional judgment.

The present teaching situation ranges from an utter neglect of the cost aspects of engineering to able supplements of purely theoretical work by separate courses in engineering economics and ingenious introductions of this work into the teaching of technical courses by way of engineering problem and engineering project work. The straining for an ideal whose attainment seems practically futile at this time demands an open-minded attitude and experimental attack.

One thing seems certain, the introduction of the teaching of the elements of engineering economics * early in the engineering curriculum should cultivate an attitude of curiosity about the cost aspects of the technical work which follows, provoking questions in the classroom and out concerning these matters in relation to all engineering work with which the student comes into contact.

* Used synonymously with "cost aspects of engineering."

Another thing seems practically certain, the treatment of engineering from the economic view-point should give stability and enrichment to any work the student elects in classical economics and other social studies, furnishing him with a pavement to walk upon when exposed to fine-spun economic theories wherever encountered. The teaching of the elements of engineering economics to sophomores and even to freshmen is aided by the simplicity of the mathematical concepts involved and their ready illustration with examples drawn out of the student's own experience with respect to such matters as the purchase of commodities, transportation, insurance, and other economic experiences within the bounds of the student's everyday life. Matters of judgment can not be taught—but the part which judgment must play can be carefully pointed out.

The proper injection of cost aspects into technical teaching probably must await the generation of a race of teachers imbued with the importance of these aspects of their work, sensitive to the proper balance to give cost factors so as not to weaken their handling of the technical aspects, and able to introduce such material into their teaching in an interesting stimulating manner. Greater attention to this work now cannot help but result in such a race of teachers in the future; it may be that patient encouragement of this kind of evolution in teaching is as far as it is possible to go in this direction at the present time. More revolutionary methods of teaching such as are now being introduced in Yale School of Engineering and such as is represented by the coöperative type of course afford greater opportunities to achieve normal relations between engineering economy and technical work. Perhaps the future will bring even more effective methods.

The engineering problem work and engineering project work serve admirably as vehicles for the teaching of the cost aspects of engineering to students in the upper classes with more technical background. The coming of the comprehensive examination and more attention to the development of the professional engineer in school and after school affords an opportunity and stimulus respectively to the viewing of cost aspects in their true professional light. The devotion of considerable portions of professional elective courses and highly specialized technical courses relating closely to industry, to problem and project work gives an adequate teaching basis for treatment of the cost aspects offered in no other place in the engineering curriculum. Such treatment is not as satisfactory as a more unobtrusive way of reflecting all technical work against its natural background of engineering economy. The matters involved are relatively simple and separate courses and great emphasis serve to disturb the more natural

relations which would be enjoyed in the ideal teaching situation approached much more closely in industry's post-school preparation courses. Nevertheless, these methods are the best to be had under present conditions.

Experimental attempts to make the students "cost conscious" in interesting bulletin board displays of actual engineering projects in association with their costs, working up costs for others willing to present them in their particular phases of teaching, and the grasping of every direct and indirect opportunity to promote the interest of the student in the cost field without in any way subordinating the technical aspects of engineering seem worth while in tackling this important and inadequately treated matter in the field of engineering education today.

Strange as it may sound, there are those who in all sincerity have remarked that a change in economic system will invalidate the very basis and content of what is defined as engineering economy, that so much emphasis upon the importance of cost aspects is giving too much stress to a matter which will lose its significance upon the experience of major changes. The writer for one believes that there are certain economic truths which are absolute enough to live through such major economic changes, that methods for choosing between alternatives and the evaluation of the best choice for the individual and society in the realm of economic selection and economic replacement will be required in any kind of an economic system and that the engineer will find it his job to apply such methods. It is admitted that time can be frittered away on unimportant phases of the cost aspects of engineering; teaching, however, as in the case with technical aspects, should be focused upon fundamentals, those elements having a basic relation to processes and methods comprising the thought structure representing the clearest thought about matters in that particular field.

ENGINEERING ECONOMICS, WHY? WHERE? WHAT?

By GEORGE W. BARNWELL

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First, I should like to define "engineering economics" or "economics of engineering" as the term is used in this paper. In many instances, the term is applied in a much narrower sense than that in which it is used here. A treatment of depreciation, from a financial as well as a physical standpoint, a few problems in comparative costs of alternate design, perhaps something on compound interest or capitalizing of the returns, and the job is supposed to

be done. I have in mind, in using the term, all subject matter in the field of applied economics which is generally conceived to be helpful to the student engineer in pursuing his future program. A shorter definition might be "the fundamentals of business practice." The subject matter may vary from course to course and from one school to another and with good reason. These variations may be due to first, the major aim of the engineering courses; second, the size of the college; and third, the background of the teaching staff.

The trend is definitely towards a greater amount and variety of material, in both the offered and required courses. When I was a student at Georgia Tech twenty-five years ago a brief course in economic theory, given by the English department, was deemed sufficient preparation for the engineer. At M. I. T., where I registered later, I was required to do additional work in several fields of engineering but no one questioned my fitness as regards things economic. My knowledge of accounting went no farther than a hazy distinction between a balance sheet and an operating statement. A course in power plants included some mention of the comparative costs of construction and operation of hydro versus steam plants. If problems in the field of engineering economics were offered, they failed to impress me sufficiently for me to remember whether or not they were even given. While these conditions may not have been typical, I think it safe to say that in the engineering curricula of that period, engineering economics was conspicuous by its absence.

You are all familiar with the developments in this field in recent years so I shall not dwell on them here. It is the object of this meeting to review these developments in the light of our personal experience with them, so that we may plan more intelligently for the future.

WHY?

Perhaps a discussion of "why?" teach engineering economics may seem superfluous, yet there are industrial leaders today who feel strongly, if one is to judge by their statements, that there is no place in engineering curricula for the study of business practice. These men would have the engineer, throughout his career, stick strictly to his technical work, leaving its economic consequences to be judged by business men.

As an answer to this group I would offer the experience of engineers generally. Statistics indicate that within a few years after leaving college, the majority of graduate engineers are *not* making their living in technical engineering activities; that after twenty-five years, or before they are fifty years old, over seventy-

five per cent are doing work which only by a severe stretch of the imagination could be called engineering.

One may argue that it is because of their intensive technical training that engineers succeed in graduating into other fields. More and more, it is being recognized that an engineering education is a good background on which to build. I was surprised to learn recently that one of the large department stores in New York numbered five graduates of M. I. T. among its executives and not one of them was in charge of the power plant. A few years ago I was told by the general manager of another large department store in Philadelphia that, in taking on young men to train in his organization, he preferred engineering school graduates to business school graduates. The baccalaureate address at Stevens this year was given by a graduate of the class of 1921. This man is now an Episcopal clergyman, and told us that his engineering training was a definite help to him in the ministry.

It seems to me only common sense that the student engineer should be given a foretaste of what he has a three-to-one chance of encountering in his later life. Practically all of the graduates of past years—before the introduction of such courses into the curricula—decry the fact that they were not given a more intensive training in accounting and other subjects which I would place under the head of engineering economics.

Aside from the bread and butter aspect of the question, there is also the cultural side to be considered. The object of our engineering schools is to produce good engineers, but this does not mean "human slide-rules" or "greasy grinds." The engineer has done much to advance civilization. This is readily admitted by all. There are those who would have us believe that he has done too much—at least in a material way.

But the engineering profession, I fear, has had less than its rightful share in the moulding of public opinion. Too often the engineer has done his work "on order." It is eminently proper, it seems to me, that the engineer begin to think of the economic consequences of his work. It is a curious fact that in this "machine age," for which the engineer is held largely responsible, labor relations in industry have assumed an increasingly important rôle. This is true of the personnel problem in the individual plant, or industry, as well as the larger problem of unemployment and economic insecurity. How many engineering schools today require or even offer their students courses in labor problems?

Another problem of major proportions is that of our natural resources and their conservation. Again the work of the engineer takes him close to such matters. He has been guilty of fostering the ruthless exploitation of our natural resources, with little regard

for the economic consequences. Would not at least a brief treatment of this problem be in order?

I am well aware of the woeful lack of time in engineering curricula for an adequate treatment of the many phases of engineering economy that are readily admitted to be desirable. I am merely emphasizing the fact that there is reason enough why we should do what we can in the time allowed to make the student economics-conscious.

WHERE?

The question of "where?" really resolves itself into two questions. The first where is a "when?"—at what time during his four years should the student receive his training in engineering economics?

Perhaps the majority opinion favors the senior year, since the senior, being more mature and having taken other courses, is able to grasp more readily the subject matter offered. Perhaps also there is the belief that the student will remember best, and hence apply most effectively, that subject matter last absorbed. This is no doubt true, but I should like to offer a few suggestions on the other side of the question.

Having taught pure and applied economics to sophomores, juniors and seniors for a good many years, I see no appreciable difference in the performance of the different classes—at least not enough to warrant the deferment of courses on that score alone. I should much prefer to spread the courses in this field over the last two or three years rather than to introduce the subject in large concentrated doses in the final year.

There is a question of psychology involved here. It is presumed that, among other objectives, there is that of making the student economics-conscious, so that he will continue to view his engineering activities in the light of their economic effect. If this be true, then the earlier the economic aspects are introduced and the more nearly they parallel the technical subjects, the better should be the results. For a student to reach his senior year without this contact, especially where the courses are offered as electives, tends to create the impression that, perhaps after all, the subject is an afterthought, put in to fill out the curriculum and hence relatively unimportant.

It seems to me that if engineering economics is introduced as early as the sophomore year that the student is able to choose his courses in this field more intelligently when he reaches his electives. In any event the training should be continuous and progressive. For instance, the principles of general accounting and

cost keeping may be introduced as early as the sophomore or junior year and then practically applied in connection with specific engineering problems in the senior year.

The second aspect of "where?" is really "by whom should the courses be taught?" This raises the question of whether engineering economics should be taught in the several engineering departments by the same staff which teaches the engineering courses or by a separate department, staffed by specialists who may lack some of the detailed knowledge of each engineering field, but through special training can tie up the problems common to all.

Much can be offered in support of the arrangement first mentioned. Where the department is really interested in doing the job well, as is true in many cases, it is an entirely satisfactory solution. But are engineering departments always interested? I believe that a careful survey would prove otherwise. I have seen department heads in the same school as far apart as the poles on this question. At one extreme we find the engineering professor who feels that economics is not the field of the engineer and that the time allowed is all too short for him to squeeze in the growing body of knowledge which is peculiar to his own particular division. At the other extreme is the department head who is willing to sacrifice some of the time formerly devoted to engineering subjects to allow for a more extended treatment of the economic aspects, even when these are given in a separate department from his own.

It is quite natural that a teacher of engineering should regard his particular subject as all-important. If he keeps up with all that is going on in his own particular field and especially if he is carrying on engineering research at the same time, it is not likely that he will find the time to devote to economics.

Even where the several engineering departments are interested and are each honestly trying to do a good job in teaching the economic aspects as applied to their particular fields, there is likely to be a considerable amount of duplication. Of course this may be obviated by a high degree of coöperation. If not, the student may wonder why so many people are teaching him the same thing in perhaps many different ways.

Provided the right kind of personnel is available, I am inclined to favor the specialized department to teach engineering economics and if the course is given I would include economic theory. The teaching staff should all be graduate engineers with a minimum of five years industrial experience, preferably more. While some specialization is allowable in such a department, especially a large department, all of the staff should be well versed in the several specialized fields of pure and applied economics. The proper functioning of such a department requires a type of diplomacy

and a spirit of coöperation not necessary to the same extent in other departments.

WHAT?

In discussing "what?" should comprise the subject matter of the several courses in engineering economy, one cannot be dogmatic. There is a rather general feeling that all engineers should be given a first course in economic theory. Most engineering schools have such a required course. Second in frequency perhaps is general accounting, in many cases followed by some treatment of costs or cost accounting. Depreciation is treated at some length, as a rule, since it is a live problem in all engineering work. Interest and compounding, sinking funds, valuation and rate making and analysis of financial statements are less often given; taxation and insurance rather infrequently; labor relations and natural resources least often of all. Management or production control is usually a required course for students majoring in Industrial Engineering, and offered as an elective to those majoring in Mechanical Engineering, Electrical Engineering, Civil Engineering, etc. There is no standard pattern.

Where the time permits, I favor an intensive course in economic theory taught by an engineer-economist, since he can draw his illustrations from the field of engineering and in general "talk the student's language." This I think is an important point. Where the course is omitted, a substitute should be introduced in the technique of presentation of the other courses.

Accounting can be taught in a few weeks if the executive's approach is used. In this treatment the logic rather than the practice is stressed. Emphasis on forms and other details is minimized. Somewhat the same may be said of cost accounting—where there is no standardization anyway. Greater emphasis should be placed on the importance of overhead and its logical distribution. The cost of idleness should be stressed. Probably depreciation is given adequate treatment at present, but there is evidence indicating that the subject will assume greater importance and receive a somewhat different treatment as time goes on. Obsolescence as an element of depreciation should be stressed.

The principles of valuation and rate making are not only important in themselves, but the treatment of these offers an excellent opportunity to stress the legal foundations involved. One might question the propriety of introducing courses in insurance and taxation into the engineering curricula, but certain of the high spots, such as the co-insurance clause, and a brief treatment of property taxation, are in order.

To the "why?" "where?" and "what?" of engineering economics I should like to add a "how?". It will be noted that it too is in the form of a question although I shall proceed to answer it.

There are, in general, three ways of teaching engineering economics. First, the rather general statement of principles, with illustrative examples sometimes added; second, the case method, using fairly simple and briefly stated cases, the principles being developed from these cases; and third, by the use of a single involved problem or case, the various aspects to be worked out during the time allowed for the course.

All of these methods have their merits and the one best suited to a specific situation is largely a matter of the time allowed for the course and the funds available for the preparation of the material. Good case material is most desirable, but it is also expensive to prepare, and new material should be given as frequently as possible, first to keep in line with current events and second, so that the solutions of the same old problems, given year after year, will not become classic literature among the students.

Where a high degree of coöperation exists among the several departments, case material can be and should be prepared jointly, to the benefit of the departments as well as the students. In cases where coöperation is lacking, there is a special need for the engineer-economist, who, being familiar enough with the several specialized fields of engineering, can prepare suitable material for his courses.

Original material from the actual field of engineering and business is best of course, and where mimeographed notes are used, new material may be added or substituted from time to time and the notes kept up-to-date. Where the expense of preparing original material is prohibitive, carefully prepared books are in order. There are several such texts now published on single phases of the subject. It is hardly conceivable that an all-inclusive treatment could be offered in one volume.

A COURSE IN ENGINEERING ECONOMICS

By DONALD B. PRENTICE

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The introduction of courses in economics in the engineering curriculum has presented a number of difficulties. Faculties have been forced to drive a wedge into the traditional program of twenty years ago and insert amounts of economics much smaller, or at least shorter, than the requirements established for arts and science students. This has necessitated selection and compression, and

explains the delay on the part of some engineering colleges in accepting the findings of the Wickenden report and the recommendations of their own alumni. The report shows a variation of credit hours in the general field of economics, theoretical and applied, from nothing to fourteen.

The difficulty of finding time for these subjects has led, in some instances, to a concentration on applied economics and the omission of a course in principles. The weakness of this arrangement is equivalent to the weakness of a course in applied mechanics without a prerequisite course in physics. Applications in economic affairs as well as in engineering may change, but principles will still be principles. And it is no answer to assert that the inexactness of economics emphasizes the lack of principles. Nothing is more exact than the fact that industry must have labor, capital and management, regardless of the system under which it is organized. The relationship between money income and real income, for example, is a principle of economics as permanent as the relationship between relative and absolute velocities in mechanics.

If we assume, to begin with, the desirability of a course in principles, what applications should we add and how can we possibly find the necessary hours in an overcrowded curriculum? This paper will discuss one solution of these problems.

While other subjects will be recommended by a few, I believe most engineers consider that some knowledge of accounting, both general and cost, of industrial organization and control, and of business finance should be possessed by the graduate if it is possible to include these subjects in his curriculum. I am not considering business law and specification writing as economic subjects, and I classify manufacturing methods under engineering.

A course in the principles of economics plus the courses in accounting, organization and finance, if of the traditional length, would require fifteen credit hours at least; more than most engineering faculties are prepared to allow. I believe the solution of the difficulty lies in a combined course, where the repetitions of independent courses can be omitted, and one example can illustrate material in two or three fields. The economist, teaching engineers, can profit from the experience of the mathematician with combined courses in algebra, trigonometry, analytic geometry and elementary calculus. Just as one mathematics problem may illustrate the relationship of algebra, analytic geometry and calculus, so one problem in budgeting may illustrate accounting, finance and management.

In general, engineering students can progress much more rapidly in a course in the principles of economics than can arts students. The former's training seems to prepare them well for

the type of thinking and reasoning which is required. The engineering students are accustomed to a condensed presentation of material; they expect a great deal of information on a few pages. A serious difficulty in teaching them economics is that of finding a satisfactory textbook. Most texts are too verbose; the treatment should be concise. I have frequently had students ask why the author took so long to tell his story and repeated himself so often. A textbook for a course in the principles of economics should not be longer than four hundred and fifty or five hundred pages. And this can be covered satisfactorily in a two credit semester course. Three credits would allow more reference and problem work and the course would be improved; but two credits will do. A teacher of economics in an arts college, accustomed to a six credit allowance of time, will ridicule this statement, but my observation has been that such teachers know little of the capacity and performance of an engineering student. Of course, economics should be taught by subject and not by pages. I am using total pages merely to illustrate the conciseness of the text.

After acquiring a general familiarity with the principles, the student enters the combination course of applied economics. Engineering students are accustomed to studying drawings, designs of structures. They understand that from the drawings the method of operation of the device can be learned. Some calculations based on the dimensions of the drawings will prove the safety of the structure; the kind of material to be used is indicated. In short, a full set of drawings conveys to the careful student a complete understanding of the technical aspects of the structure. By analogy a complete financial statement will convey to the careful student an understanding of the economic aspects of an enterprise.

Our combined course, therefore, opens with the study of a dozen or fifteen financial reports. Pairs of similar companies are chosen; for instance, the General Electric and the Westinghouse; American Smelting and Refining and the U. S. Smelting, Refining and Mining; Anaconda and Kennecott. Each item in the balance sheet and earnings statement is explained and the various ratios are calculated and interpreted. Students are sent to one of the standard manuals, Moody's for instance, to work out problems from other financial statements for comparison.

When a general familiarity with the material has been secured a detailed study of the several items is commenced and the related subjects are introduced. For example, if the first item is "fixed assets" the principles of valuation are considered and methods of calculating depreciation are studied.

The liability sides of the balance sheets, if chosen carefully, will present most of the methods of raising capital, bank loans,

common and preferred stocks, and the wide variety of bonds and notes.

Time does not permit an elaborate and detailed statement in this paper of all the material which can be presented when the financial reports are used as the starting point; but it should be evident that all the subjects of a course in business finance and much of the usual course in industrial management will be introduced by items in the balance sheet and earnings report.

After studying the financial statements so thoroughly and realizing how completely the management policies are reflected in the figures, a student becomes curious as to the methods by which these statements are constructed. In moving picture parlance a "flash-back" is then given of the accounting procedure which led to their compilation. Knowing well the ultimate purpose, a student grasps the routine of accounting rapidly and can differentiate clearly between procedures arriving at cost determination and those designed to present the general financial condition of the company. Double entry bookkeeping for a small concern is carried in the usual way for the transactions of a month and the standard closing procedure is reproduced.

There are a few subjects of the usual course in industrial management which cannot well be related to financial statements, for example, the personnel policy. These must be studied as separate divisions of the combined course, but experience has shown that they do not involve many class periods; the subject matter is largely descriptive.

Under the procedure described rather briefly in this paper a combined course of four credits in engineering economics can present to the students in a satisfactory manner the important material ordinarily included in courses in business finance, accounting, and industrial management, totalling nine credits. The analogy between financial statements and engineering drawings is readily grasped by students familiar with the latter, and the pedagogical advantage of demonstrating and emphasizing the purpose of a course at its outset is of considerable value.

Together with the two credit course in "principles" this combined course carries the students through the desired range of economic subjects in a total curriculum allotment of six credits in three semesters. Simultaneously the economic aspects should be emphasized in the traditional courses in engineering, such as power, machine design, hydraulics and structures, for the experience of the last five years has proved the uselessness of technical skill without due consideration for the financial success of an enterprise.

ECONOMICS AND ENGINEERING ECONOMY

By LAWRENCE R. GUILD

Professor of Management Engineering, Carnegie Institute of Technology

If you were to place before you, side by side, any one of the better known textbooks on Economics, such as the fifth edition of Ely's "Outlines of Economics," and such a book as Grant's "Principles of Engineering Economy," open them to their respective tables of contents, and make a comparison, you would find a wide divergence in the subject matter and method. You would think, "Truly, here are books which treat of quite different subjects." But do they? And if they do, why do they? Wherein lies the difference?

Undoubtedly the difference has its origin in the training of the authors. An Economist is usually trained as an undergraduate by means of a Liberal Arts major in Economics in which he is more likely to range over the entire field than he is to study intensively any one phase. Then he progresses to graduate work. Graduate work sees more intensiveness and concentration, usually with a tremendous amount of reading, with an effort to evaluate the "literature." Bright young men learn to identify a writer's opinions as originating in, or influenced by, this or that other writer. "Schools of Economic thought" are identified. The "field" is fairly well marked out, and is typified by the material indicated by the table of contents in Ely. Inductive and deductive methods are both used. Sooner or later, the average Economist, by inclination or in self-defense, narrows down his efforts to some phase of the subject with which he can cope and become more or less expert. He may, if he be a professor, continue to teach "a section of the elementary course," but his active and creative interest is elsewhere. He does not spend his time trying to re-state the basic principles, nor to delimit the scope of the subject. Or if he be a hardy soul who does try to do so, he is apt to end up with something surprisingly similar to that from which he sought to depart; unless he succeeds merely in substituting description for analysis. Finally, it should be borne in mind that a discouraging lack of factual material all too often forces him back to a dependence upon logic unsupported.

The author of the other book is an Engineer. An Engineer is trained to deal objectively with facts and things. He experiments; he calculates. He usually is trained to be a particular kind of Engineer, so that he also becomes something of a specialist. He is, nevertheless, likely to find himself working in some other capacity. His theories are accepted because they are susceptible of proof.

TABLE I

This tabulation shows the Chapter headings in Ely and in Grant, as suggested in the first paragraph

Ely	*Grant*
1. The nature and scope of Economics.	1. What is economy?
2. The evolution of economic society.	2. Comparisons of immediate economy.
3. The evolution of economic society.	3. Will an investment pay?
4. The economic development of the U. S.	4. Significance of compound interest.
5. The economic development of the U. S.	5. Depreciation as a factor in economy studies.
6. Elementary concepts.	6. Comparisons of ultimate economy.
7. Production.	7. Investment costs and sunk costs.
8. Consumption.	8. Load factor and the economies of capacity.
9. Value and price.	9. When should a machine or structure be replaced?
10. Value and price.	10. Design for increasing demand.
11. Value and price.	11. Fact finding for planned development.
12. Value and price.	12. Engineer's use of accounting records.
13. Money.	13. Technique of estimating costs.
14. Credit and banking.	14. Engineering applications of statistical method.
15. Credit and banking.	15. Technical fact finding and research.
16. Money and prices.	16. Engineering point of view in economy studies.
17. Business cycles.	17. Some judgment factors related to the character of enterprise.
18. International trade.	18. Judgment factors related to problems of financing.
19. Protection and free trade.	19. Judgment factors related to forecasting.
20. Distribution as an economic problem.	20. Other types of judgment factors.
21. The wages of labor.	21. Social implications of engineering economy.
22. The rent of land.	22. The human element in judging economy.
23. Interest.	23. Expression of the results of economy studies.
24. Profits.	
25. The personal distribution of wealth.	
26. Business organization.	
27. Monopoly and trusts.	
28. Transport economics.	
29. Agricultural problems.	
30. Insurance.	
31. Labor legislation.	
32. Labor problems.	
33. Socialism.	
34. Public expenditures.	
35. Public receipts from loans and government ownership.	
36. Public receipts from fees, special assessments, and taxes.	
37. Public receipts from Federal, State and Local taxes.	
App. A. History of economic thought.	

They work. Formulas can be made and used because natural forces and objects can be understood well enough generally to permit of definite predictions.

We might say, then, that economics has developed around the word *"why."* Engineering has been built up to know *"how."* Sooner or later each word gets into the territory of the other. The Economist who explains *why* prices move up and down is called upon to tell *how* they are likely to move under certain conditions, or at some given future time. If he can ascertain all of the details of the situation, he can tell this. This involves both understanding of the background, and the facts of the immediate situation. It is said, and quite correctly, that a person who can tell by reading the front page only of his daily newspaper what to buy and what to sell, is the only person who should dare to invest his money in stocks and bonds. It is hard to know the *"how"* when human factors of greed, fear, politics, and emotions generally, are involved.

But if the world, and his own work, make the Economist consider "how" as well as "why," somewhat similar forces demand that the Engineer understand "why" as well as "how." He knows *how* to build bridges across the Hudson River and the San Francisco Bay, but before he is permitted to build, there is asked the question, "Will it pay?" This is the "why" of it. It might be just as feasible technically to bridge one of Norway's fjords, but there seem to be definite economic limitations.

It would seem that there is an obvious conclusion. The Economist and the Engineer need each other's coöperation. The traditional economics needs clarifying and codifying. It has become so wide in scope that the elementary course all too often skims the surface. At the same time, its leading exponents are apt to be busy as money doctors, marketing experts, authorities on taxation, and the like; or they become embroiled in discussions reminiscent of the question of how many angels could dance upon the point of a needle. The Engineer, faced with an immediate question of costs versus returns, is in just as great danger of ignoring all but the direct aspects of his problem.

If the economist can bring his subject down to a plane more immediately usable his work will have more appeal to the Engineer. If the Engineer realizes that he must seek beyond the mere answer to "will it pay," he will be ready to influence economics. If the Economist cannot, or will not, develop the practical side of his subject, let the Enginueer do it for him. If the Engineer cannot, or will not, appreciate the value of the broader subject, there is no reason why the economist should not utilize engineering methods to improve his material and method.

Conditions change too rapidly nowaways to permit any longer the use of traditional methods merely because they are traditional. Engineers and Economists—yes, business men, politicians, and housewives—ought to know the basic economic principles so well that we should have automatically a planned economy. Everyone should be so well grounded that cause and effect could be clearly seen, and guesswork eliminated.

Let the Engineers and Economists join forces. The Engineers can inject a certain practicality into the field of economics; the Economist may help to extend the vision of the men in engineering. From this combination of "how" and "why" should come a more healthy society. As the physicians hope, with the aid of scientists in other fields, eventually to place medicine largely upon a preventive basis, is it too much to hope that Economist and Engineer will someday make this subject clear enough and complete enough that most, if not all, economic ills may be dealt with preventively, and that people in general will know how to maintain their individual economic well-being?

NECROLOGY

Professor William T. Magruder, one of the founders of the Society for the Promotion of Engineering Education, and for almost thirty-five years Head of the Mechanical Engineering Department of Ohio State University, died on June 21, 1935, at his home in Columbus, Ohio.

Professor Magruder was born April 22, 1861, at Baltimore, Maryland. He graduated from Stevens Institute of Technology in 1881, and in 1921 the degree of Doctor of Engineering was conferred upon him by this same institution.

For five years following his graduation he served as draftsman and designer for the Campbell Printing Press and Manufacturing Company, Taunton, Massachusetts, after which he returned to college, this time to Johns Hopkins University, for graduate study in mathematics and chemistry. In 1887 he accepted the position of Chief Chemist of the Mt. Clare shops of the Baltimore and Ohio Railroad. He resigned this position a year later to become an instructor in mechanical engineering at Vanderbilt University. The following year he was advanced to Adjunct Professor of Mechanical Engineering. In 1896 he served as Chief of Machinery, Tennessee Centennial Exposition. That same year he came to Ohio State University as Professor of Mechanical Engineering. He served the University for a total of thirty-seven years; first as Chairman of the Mechanical Engineering Department until 1929, when he resigned the chairmanship but continued actively as a professor in the department until he was made Professor Emeritus in 1933.

Throughout all of Professor Magruder's busy life he took a great interest in engineering education. He was an active worker in S. P. E. E. from its inception until his death. He was a councillor 1899–1902 and 1907–1911; vice-president 1905–06, secretary 1906–1907, and president 1912–1913. He was chairman of the local committee which handled the arrangements for the annual meeting which was held in Columbus in 1929. He also belonged to many other educational, engineerng, and fraternal organizations, and was honored by office in a number of them. In the American Association for the Advancement of Science he was Secretary of Section D from 1899–1900 and from 1902 to 1907 He served on the Council of the American Society of Mechanical Engineers for several years, and was vice-president from 1925–1927. He was

councillor of the American Association of University Professors, 1915–1916, president of the Columbus Engineers Club 1904–1905 and president of the Ohio Society of Mechanical Engineers 1905–1907. In 1917–1918 he was in charge of the Department of Engines, U. S. A. School of Military Aeronautics in Columbus. From 1930 until his death he was a member of the national Executive Council of Tau Beta Pi. He was also a member of Sigma Xi, Beta Theta Pi, and of the Masonic Order. He was a zealous member, and for a large part of his life, a lay-reader of the Protestant Episcopal Church.

He was the author of numerous scientific papers which were presented at meetings of societies to which he belonged or published in technical journals and of many papers dealing with educational problems, most of which may be found in the *Proceedings of the Society for the Promotion of Engineering Education.*

He was a man of high standards and ideals. His self-sacrificing service and constructive activities, his energy, loyalty, and broad interests, which brought him so many honors during life and made him such a valuable member of the university community and of each organization to which he belonged, will indeed cause him to be sorely missed by his many friends and colleagues.

INTERNATIONAL COMMITTEE ON WEIGHTS AND MEASURES

The following information was approved for general publication by the International Committee of Weights and Measures at its meeting in October, 1935, at Sevres, France

1. In accordance with the authority and responsibility placed upon it by the General Conference of Weights and Measures in 1933, the International Committee of Weights and Measures has decided that the actual substitution of the absolute system of electrical units for the international system shall take place on the 1st of January, 1940.

2. In collaboration with the national physical laboratories, the Committee is actively engaged in establishing the ratios between the international units and the corresponding practical absolute units.

3. The Committee directs attention to the fact that it is not at all necessary for any existing electrical standard to be altered or modified with a view to making its actual value conform with the new units. For the majority of engineering applications the old values of the international standards will be sufficiently close to the new for no change, even of a numerical nature, to be required. If for any special reason a higher precision is necessary, numerical corrections can always be applied.

4. The following table gives a provisional list of the ratios of the international units to the corresponding practical absolute units, taken to the fourth decimal place. Since differences affecting the fifth decimal place exist between the standards of the international units held by the various national laboratories and also because all the laboratories which have undertaken determinations of the values of their standards in absolute measure have not yet obtained final results, the Committee does not consider it desirable for the present to seek a higher precision. At the same time it hopes that it will be possible to extend the table of these ratios with a close approximation to the fifth decimal place well before the date fixed for the actual substitution of the practical absolute system for the international system.

TABLE

1 Ampere	International	= 0.999 9	Ampere	Absolute
1 Coulomb	"	= 0.999 9	Coulomb	"
1 Ohm	"	= 1.000 5	Ohm	"
1 Volt	"	= 1.000 4	Volt	"
1 Henry	"	= 1.000 5	Henry	"
1 Farad	"	= 0.999 5	Farad	"
1 Weber	"	= 1.000 4	Weber	"
1 Watt	"	= 1.000 3	Watt	"
1 Joule	"	= 1.000 3	Joule	"

AMERICAN ENGINEERING COUNCIL

Delegates from the forty-two member organizations of American Engineering Council, meeting in Washington, January 10 and 11, discussed the growing evidence of unity in the profession as to the formulation and dissemination of opinion on matters of public affairs. The Assembly acted upon reports from sixteen major and minor committees and sub-committees of the Council. President J. F. Coleman opened the meeting with an address on the essential elements in reviving the construction industry. Then followed in order a series of reports and discussions covering a wide range of subjects of timely interest to engineers.

Survey of the Profession

George T. Seabury, as chairman of the Engineering and Allied Technical Committee, reported on the "Survey of the Engineering Profession" conducted by the Bureau of Labor Statistics of the U. S. Department of Labor. Dr. Isador Lubin, Commissioner of Labor Statistics, presented some preliminary figures. His report, based on returns from more than 60,000 questionnaires, the largest survey of this kind ever conducted, indicated that the findings would tend to give direction to engineering education, to choice and distribution of occupation, and to compensation of engineers. It is expected that full returns will be available in the early spring. It was voted to recommend to the Executive Committee of Council that steps be taken toward private publication of a mass of detailed information to supplement the government report.

Leonard D. White, U. S. Civil Service Commissioner, discussed the needs for a widely extended civil service to include state and local governmental bodies as well as federal, in order to uphold the professional standards of engineers in the public service. Discussion developed that classification by position is essential in the development of a suitably paid civil service. It was voted to instruct the Executive Committee to take the steps necessary to put these basic concepts into action, especially in coöperation with local and state engineering societies.

Economic Balance Toward Higher Standards

Ralph E. Flanders presented the third progress report of the Committee on the Interrelations of Production, Distribution and Consumption. In 108 classified questions and answers, there was

presented a catechism on the engineers' concept of the possibilities of an economic balance in the interests of a high standard of living for all. The report was accepted with the recommendation of the Committee that all delegates study it, secure local discussion on its major objectives and detailed recommendations, and report back February 1st, with the plan of presenting the report publicly as soon as possible thereafter as the engineers' contribution to our national welfare.

Charles W. Eliot, II, executive officer of the National Resources Committee, discussed the purposes and plans of that body in forwarding a state and local as well as a federal concept of planning. The need of approaching planning from a local and regional viewpoint was especially emphasized. It was voted to refer the bill (S-2825) now before the Senate, providing for the continuation of the federal organization on a permanent basis, to the Public Affairs Committee of Council for recommendations.

Public Affairs Reports

The Public Affairs Committee of American Engineering Council, under the chairmanship of F. J. Chesterman of Pittsburgh, has been organized under a new plan during the past year with several sub-committees active in studying public programs which fall within the purview of the profession. For coördination, the sub-committee chairmen are members of the national committee and steps are being taken to make the membership of sub-committees overlap with that of similar committees of national, state and local engineering societies. As a result of this work, the reports rendered at the Annual Meeting cover basic findings in a broad variety of fields.

The sub-committee on the Administration of Public Works, F. M. Gunby, chairman, reaffirmed Council's past position that engineering public works of the federal government, in so far as practicable, should be concentrated under one qualified head.

The Water Resources Committee, headed by W. S. Conant, reiterated its belief in two fundamental needs for the formulation of a water resources policy: (1) Complete and coördinated basic data bearing on the subject and (2) comprehensive study of water control legislation. The establishment of a body similar to the Board of Surveys and Maps of the Federal Government for the correlation of government data on water resources was recommended.

As a result of the work of the Aeronautics Sub-committee, headed by Grover Loening, the Public Affairs Committee adopted a report supporting aeronautical research by the colleges, disfavor-

ing further investigations of the industry, recommending further studies toward the simplification of aircraft construction regulations, and favoring the placement of employes of the Bureau of Air Commerce under Civil Service.

The Committee on Competition of Government with Engineers in Private Practice, under the chairmanship of Alonzo J. Hammond, advocated the curtailment of competitive activities by government and the raising of consulting fees by public bodies to a basis comparable to private practice.

Rural Electrification

R. W. Trullinger, of the U. S. Bureau of Agricultural Engineering, reported on the activities of a sub-committee, made up of members of the American Society of Agricultural Engineers, a member body of Council, to forward the rural electrification program through the aid of engineers. It was voted that this work continue under a committee representative of the profession as a whole.

The Assembly received a report of the Committee on Patents, Dean A. A. Potter, Chairman, dealing with the elimination of fraudulent practices, the use of a single signature on patent applications, the validation of joint patents, and the extension of the full rights of inventors. In addition, several specific items of legislation were presented as under consideration by the committee. It was recommended that the work of the committee be continued.

Mapping

The Assembly adopted the recommendations of the Executive Committee that American Engineering Council establish a new committee on Mapping and Surveys and that it endeavor to organize public opinion as to the basic need for completing the map of the United States. It was voted to support the original Temple Act to the end that its purposes be effectuated by appropriations based upon the fundamental values of mapping and not on a relief basis.

Good Fellowship Dinner

The annual All Engineers Dinner of Council was held on the evening of January 10. Following the dinner, an engrossed resolution was tendered to J. F. Coleman in appreciation for his services as president of Council during the past two years. Dr. William McClellan, president of the Potomac Electric Power Company and chairman of the Dinner Committee, made the presentation. He told how Mr. Coleman had been successful in carrying Council

through a critical period in its history. Dean A. A. Potter was introduced as the new president of Council. He stressed the need for solidarity of engineering opinion.

William F. Durand, Chairman of the Third World Power Conference, past president of ASME, and John Fritz Medalist for 1935, discussed the deeper functions of the engineer. He stated that engineers are the custodians of natural resources such as minerals, coal, and oil but are not fully living up to their responsibility in conserving these resources. The profession, he said, must concern itself not alone with technical matters but increasingly with human and social problems.

Ralph E. Flanders, past president of the ASME, directed his remarks toward a reply to a recent address by Walter Lippman before the American Medical Association. Mr. Lippman had stated that the engineer is a master of material resources but that the application of his material concepts does not work in solving human problems. Mr. Flanders stated that on the contrary every phase of the engineer's work is intensely human in its application and relationships. He predicted that engineering technique will carry the nation far beyond the "miserable physical standards of 1929."

New Officers

Council's new president for 1936 and 1937 is A. A. Potter, Dean of the Schools of Engineering, Purdue University, who succeeds J. F. Coleman of New Orleans. New vice-presidents are: Ralph E. Flanders, president of the Jones & Lamson Machine Co., for a two-year term; and J. S. Dodds, professor of civil engineering, Iowa State College, for a one-year term.

The chairmen of the Public Affairs Committee and of the Committee on Membership and Representation were made ex-officio members of the Executive Committee of Council. The present Public Affairs chairman is F. J. Chesterman. C. O. Bickelhaupt, who heads the membership group, already is a member of the Executive Committee as vice-president of Council. In addition to the above, the Executive Committee includes Alonzo J. Hammond, vice president, C. E. Stephens, treasurer, and William McClellan, chairman of the Finance Committee, who were re-elected. Frederick M. Feiker was re-elected as executive secretary.

Secretaries' Conference

Preceding the meeting of the Assembly of American Engineering Council, there was held on January 9 the Sixth Conference of Secretaries of Engineering Societies, under the chairmanship of K. F. Treschow, secretary, the Engineers' Society of Western

Pennsylvania. Some thirty national, state and local societies were represented. The morning program developed the possibilities and opportunities for coöperation and coördination on matters of public affairs through state societies, national societies, and the American Engineering Council.

Both at this session and at the subsequent Council session on Public Affairs, the development of local and state public affairs committees was carried forward and both meetings favored the further coöperation of present organizations to develop united action in these matters.

Speakers at the Secretaries' Conference included: J. F. Coleman, on Progress in Engineering Organization; General R. I. Rees, of New York, on Opportunities for Unity Among Engineering Organizations; and Col. J. M. Johnson, Assistant Secretary of Commerce, on the Engineer in Government and Business. Other topics included coöperation with national, state and local secretaries; employment activities; engineering publicity; non-technical programs; and engineering society management.

BOOK REVIEWS

The Preparation of Engineering Reports. THOMAS R. AGG AND WALTER L. FOSTER. New York, McGraw-Hill Book Company, Inc., 1935. viii + 192 pages. $1.75.

This book was written by Dean Agg and the late Professor Foster of Iowa State College, both of whom offer a background of extensive practical experience and class room instruction as a sound basis for the publication. The authors give a simple and teachable presentation of the methods involved in preparing the more important types of reports with which the engineering graduate has to deal. The book suggests the most effective ways of presenting ideas and information to a reader so that the significance of the information may be easily and readily grasped.

The opening discussion takes up the distinctive characteristics of an engineering report; next are presented the several forms of reports and their arrangements. The various types are well illustrated as to their mechanical make-up and also with regard to the presentation of the collected data on diagrams, charts, and graphs.

The four appendices are of special interest. The first deals with "style" and demonstrates the methods by reproducing a digest of the style manuals of selected engineering societies and publishers. The second lists the more important accepted abbreviations. An outline of a course on the preparation of engineering reports, of special interest to teachers of this subject, is given in the third appendix. The last appendix gives a lengthy list of references which the authors have found useful for illustrative purposes in connection with the presentation of the various factors involved in a study of the subject.

The teacher who prefers a textbook that is written concisely and contains ample examples should welcome this timely text.

E. DILLON SMITH

The Metal Iron. H. E. CLEAVES AND J. G. THOMPSON. McGraw-Hill Book Co. 574 pages, 6″ × 9″.

This is the sixth monograph published in the Alloys of Iron Research program of the Engineering Foundation. It constitutes a painstaking review and excellent presentation of available information on the preparation and properties of high purity iron. The important literature has been covered thoroughly and understandingly.

Part I, in three chapters, covers laboratory and commercial production of electrolytic iron, and chemical methods for preparing

high purity iron. Part II presents the properties of high purity iron, an introduction and nine chapters, on the following subjects: Structure; Thermal, Electric, Magnetic, Miscellaneous, Chemical, and Mechanical Properties; Heat Treatment and Aging; and Effect of Minor Constituents. An extensive bibliography gives 1081 references. There are good name and subject indices.

Primarily a data book, to assist students of iron with a ready means of knowing what has been published. Many tables and diagrams are presented showing the properties of various high purity irons as reported by original investigators, with the authors' comments on the same, appraisal of the conflicting data, and suggestions of values for tentative acceptance. A valuable feature is the authors' summary at the end of each chapter or section.

The authors have woven their presentation of the various subjects into a very readable, well coördinated story of the facts in regard to high purity iron that are available in the literature. It is an excellent book and should find wide use by student of the metallurgy of iron.

S. L. GOODALE

Mathematics and the Question of Cosmic Mind with Other Essays. CASSIUS JACKSON KEYSER. New York Scripta Mathematica, 1935. v. 121 p. $.75.

Among American interpreters of mathematics to the intellectual but non-mathematical layman, C. J. Keyser is easily foremost. Already, in "Mathematical Philosophy," "Pastures of Wonder," etc., he had rendered valuable service of this important kind. His "Mathematics and the Question of Cosmic Mind with Other Essays," second volume of the Scripta Mathematica Library, continues the fine tradition. It is a pity that other gifted mathematicians, with very few exceptions, either will not or cannot spare the time to take the mathematical watch to pieces to see what makes it tick.

Professor Keyser's definition of mathematical thinking as postulational thinking is admirable. While free from the "p" and "q" language of Whitehead and Russell, it means essentially the same thing. His skilful separation of mathematics and science, "the two enterprises which taken together embrace the whole knowledge-seeking activity of man," is a remarkable feat of intellectual histology. The instrumental value of this cleavage is perhaps not great (even Gauss was apparently not aware of the distinction) but its cultural import and its significance for a theory of knowledge are enormous. Clearly to recognize what mathematics and science are and what they are not is surely a precious insight for us who live in a civilization that is predominantly mathematical and scientific.

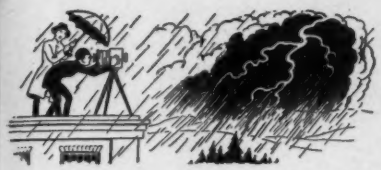
Professor Keyser is preëminently a critic who writes consciously about the critic's art and the function of criticism. The word criticism is, of course, not intended in the narrow depreciatory sense, but in the larger one of constructive analysis, synthesis and interpretation—analysis which lays bare the component parts and examines their mutual consistency, synthesis which reveals the architectural beauty of the whole, and interpretation which refers both the whole and its parts to the background of significant experience, relating them in a meaningful way to life. Professor Keyser's book is to be regarded as literature in the literary sense, not in the sense of anything whatever that happens to get into print. But in many writers of literature a strong critical faculty tends to paralyze creative effort, producing stagnation or at best fragmentary work. The result is bon mots, table-talk, diaries or obiter dicta. With Keyser the critical faculty is a strong rudder, guiding his discourse easily into channels of substantial truth. He arrives at a complete doctrine, expressed with great virility and with much esthetic finish.

The ideal of Professor Keyser, as with the Victorian Matthew Arnold, is "to see things in all branches of knowledge, theology, philosophy, art, science, as in themselves they really are." Others, of course, in great numbers, share this ideal, but I cannot refrain from thinking that there is a closer intellectual affinity than ordinary between these two, in spite of differences in temperament and fields of labor. Arnold narrowed his considerations largely to the field of literature. Nevertheless he took a disinterestedly critical stand toward politics and society in general. His chief concern, however, was poetry which he defined as "a criticism of life under the conditions fixed for such a criticism by the laws of poetic truth and poetic beauty." One may, perhaps, describe Professor Keyser's work as a criticism of life made in accordance with the laws of logical truth and logical beauty. Indeed he has in this book and elsewhere virtually identified mathematics with "rigorous thinking about anything," be it religion, law or other "major concerns of man."

The concluding essay of the volume is a splendid tribute to the American scholar, William Benjamin Smith, "mathematician, physicist, poet, philosopher, historian, teacher, and critic, . . . truly Leibnitzian in scope and versatility, in the exactness, the depth, and the immensity of his scholarship, in the catholicity and elevation of his spirit, and especially in the constructive achievements of his critical work." The book would be valuable if it did no more than direct the attention of the thinking public to this great man.

A. E. STANILAND

G-E *Campus News*



CRASH!

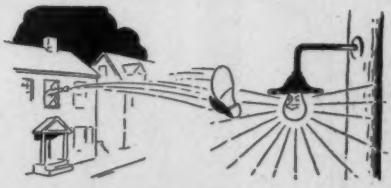
IT's a thunderstorm sweeping over Pittsfield, Massachusetts. But G-E engineers, instead of hiding under the bed, go up on the roof to be nearer the lightning. On one of the buildings of the Pittsfield Works they have built and equipped a lightning observatory. By means of an ingenious periscope and a high-speed, motor-driven camera, any lightning flash occurring within many miles—north, south, east, or west—can be automatically photographed. Its characteristics, as recorded on the film, can then be compared with those of the artificial flashes produced by the 10,000,000-volt lightning generator in the laboratory.

An observatory has to have a hole in the roof. To keep the rain from falling on the 12 lenses of the camera—and from running down the engineers' necks—compressed air is blown upward through the aperture. When next the thunder rolls over the Berkshires, and timid citizens are cowering under the bedclothes, these G-E engineers will be up on the roof taking notes on Jove's own brand of lightning.

GAME BID

DOUBLED! Redoubled! North led, but the dummy was 6000 miles away. Psychic bids flew thick and fast when a North American contract-bridge team, including Mr. and Mrs. Ely Culbertson, played a "bridgecast" tournament with a high-ranking team from Argentina. The North Americans were seated on the stage of Rice Hall in the General Electric Company, at Schenectady, N. Y., while the Argentine team played at the Casabal Club in Buenos Aires. The plays were carried by the shortwave stations W2XAF and LSX, of North and South America, respectively.

W2XAF, in Schenectady, used a feed-back circuit so that short-wave listeners all over the world, tuned to the one station, could follow the playing with as great ease as the 500 kibitzers who jammed Rice Hall. This was the first international bridge broadcast in which the principals were all recognized experts. The North American team, captained by Culbertson, won by a margin of 1030 points.



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MANY a man has shinned up a lamppost to daub paint on a street lamp that shone in his bedroom window. Many another light sleeper, of lesser climbing prowess, has tried throwing shoes and hair brushes at the offending light. Now there is hope that this war will soon be over.

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